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TRANSACTIONS

Edited by

P. H. GREGORY and G. C. AINSWORTH



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THE FUNGI

A DESCRIPTION OF
THEIR MORPHOLOGICAL FEATURES AND
EVOLUTIONARY DEVELOPMENT

BY

ERNST ALBERT GÄUMANN

*Director of the Institute of Applied Botany
Zurich, Switzerland*

TRANSLATED FROM THE GERMAN
AND ARRANGED AS AN AMERICAN TEXT

BY

FREDERICK LYLE WYND

*Professor of Botany and Plant Pathology
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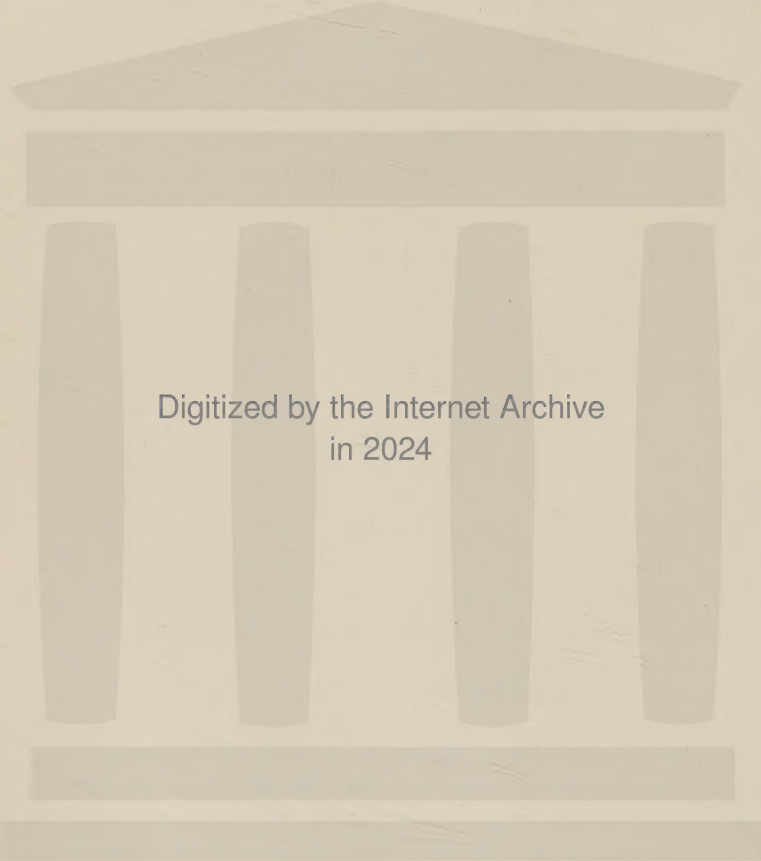
Dr Ernst Gäumann is recognised as one of the most distinguished living Mycologists, and his numerous contributions to the literature of Mycology are known throughout the world. The results of his life-long studies are summarised for the first time in

THE FUNGI

Dr F. L. Wynd has presented the text to English readers in a scholarly translation from the German. The fluent and colourful discussions which characterise Dr Gäumann's original manuscript are rendered in English with an appreciation of the subtleties of the German as well as of the English language.

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NEW AND OLD SPECIES OF *PESTALOTIOPSIS*

By R. L. STEYAERT

159 rue des Atrébates, Brussels, Belgium

(With 6 Text-figures)

In continuation of a monographic study of the genus (Steyaert, *Bull. Jard. bot. Brux.* **19**, 285-354, 1949) further species are described and illustrated on a uniform scale: *Pestalotiopsis natrassii* n.sp., *P. adusta* (Ell. & Ev.) nov.comb., *P. neglecta* (Thuem.) nov.comb., *P. gigas* n.sp., *P. owenii* n.sp., and *P. owenii* var. *major* n.var. Collections of *P. mangiferae*, *P. disseminata*, *P. royenae*, *P. theae* var. *major*, *P. papposa*, *P. virgatula*, *P. versicolor*, *P. glandicola*, and *P. funerioides* from various sources are described and annotated.

I have had the opportunity of examining a large number of collections of *Pestalotiopsis* sent to me by several correspondents. The majority were received from the Commonwealth Mycological Institute, Kew. In this publication I pursue the policy adopted when I started the study of this

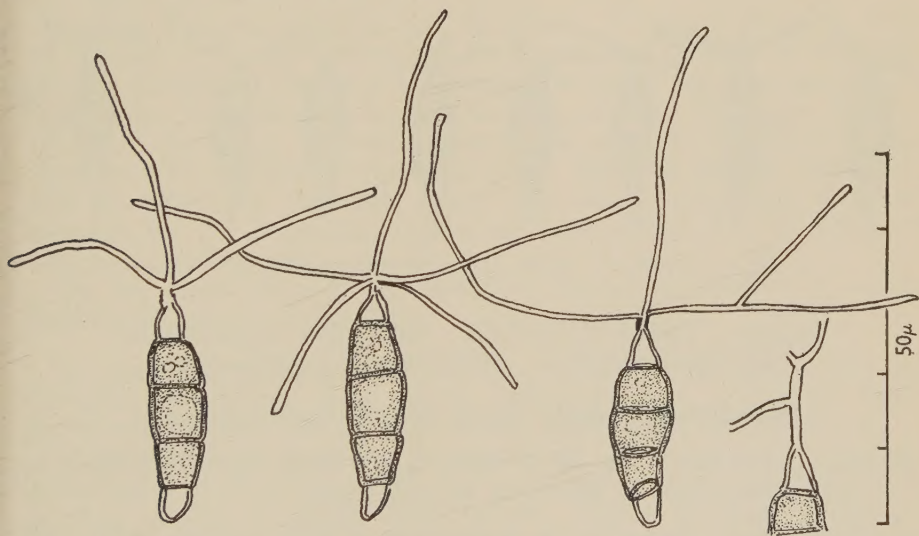


Fig. 1. Conidia of *P. natrassii*. Attention is called to the attachment of the ramifications which are inserted a little above the base of the axillary setula. (From R. M. Natrass 1292.) ($\times 1000$.)

very intricate group [R. L. Steyaert, 'Contribution à l'étude monographique de *Pestalotia* de Not. et *Monochaetia* Sacc. (*Truncatella* gen.nov. et *Pestalotiopsis* gen.nov.)', *Bull. Jard. bot. Brux.* **19**, 285-354, 1949] by illustrating all the species observed with the greatest possible detail at a uniform scale ($\times 1000$).

Section: MONOSETULATAE. Subsection: RAMULOSAE

***Pestalotiopsis nattrassii* Steyaert sp. nov.**

Conidia fusiformia, 4-septata, (24)27-29.1-33 μ $\times$ 8-8.6-9 μ ; cellulae 3 mediae concolores, brunneo-fulvae, ad septa leniter constrictae, 17-20.2-23 μ longae, duae superiores saepissime guttatae; cellulae extimae hyalinae, apice conoides, apicalis setulam ramulosam, 18-32.8-46 μ longam, 1-4 ramulis (19)24-35.4-44 μ longis interdumve subramulosis gerens, basalis conoides vel rotundatis sine pedicello (Fig. 1).

Isolated from tea (*Thea sinensis*) leaf, and cultured on potato-carrot agar, Sotik, Kenya, 2 December 1949; R. M. Nattrass 1292 (BR., holotype) (I.M.I. 38807, isotype).

A very distinct species, remarkable for its solitary branched setulae in which it resembles *Pestalotiopsis karstenii*. The branches usually arise from a slight swelling 1 or 2 μ from the base of the axial setula, or at different levels on it but always close to the base. The two upper coloured cells are guttulate, or more frequently guttate with a large gutta each. The absence of a pedicel should be noted.



Fig. 2. Conidia of *P. adusta*. (From Mauritius, Orian.) ($\times 1000$.)

Section: TRISETULATAE. Subsection: CONCOLORES.

Group: Fusiformes. Subgroup: Non-spathulatae

***Pestalotiopsis adusta* (Ell. et Ev.) Steyaert comb. nov.**

Pestalotia adusta Ell. et Ev., in *J. Mycol.* **4**, 51, 1888; Sacc. *Syll. Fung.* **10**, 486, 1892; Guba in *Mycologia*, **24**, 359, 1932.

Macules, none observable on exsiccatum. *Acervuli* 2-3 mm. diam. subepidermal, erumpent by scaling off of an irregular disk-like portion of the epidermis; mass of conidia forming a black crust visible at first by translucence under the epidermis, marked more or less conspicuously, when the latter scales off, by parallel striae. *Conidia* short fusiform, 4-septate, 16-19.2-22 μ $\times$ 5-5.6-7 μ ; coloured cells concolorous, brown olivaceous or the two upper slightly darker, guttulate, not or slightly constricted at the septa, 12-13.8-15(17) μ long; end cells hyaline, the apical short conic, bearing a crest of 2-4 setulae, 5-7.25-12 μ long (Fig. 2).

On wing, usually at the tip, of samara of *Casuarina* sp.: Mauritius, Orian, October 1950 (BR.) (I.M.I. 44035).

The acervuli differ from those observed and described by Guba on *Prunus* sp., but this may be due to features of the host tissue. The conidia are, however, in good agreement with those described by the same author.

Pestalotiopsis mangiferae (P. Henn.) Steyaert, in *Bull. Jard. bot. Brux.* **19**, 320, 1949.

Pestalotia mangiferae P. Henn. apud de Wild., in *Ann. Mus. Congo*, Ser. V, 102, 1907; Sacc. *Syll. Fung.* **22**, 1223, 1913; Steyaert, in *Bull. Jard. bot. Brux.* **19**, 173, 1948.

Conidia fusiform, 4-septate, constricted at the septa, $18-20.1-24\mu \times 6-6.5-7\mu$; coloured cells pale brown, $12-13.7-16\mu$ long; 2-3 spreading non-spathulate setulae, $9-14-20\mu$ long; pedicel $2-3.1-5\mu$.

Isolated from capsid lesions on *Theobroma cacao* L., cultured on potato-carrot agar; Tafo, Gold Coast Colony; H. Owen 718, 5 December 1946 (BR.) (I.M.I. 40648).

Pestalotiopsis neglecta (Thuem.) Steyaert comb.nov.

Pestalotia neglecta Thuem., in *Instituto, Coimbra*, II, **27**, 326, 1880; Sacc. *Syll. Fung.* **3**, 888, 1885.

(a) On *Euonymus japonicus* L.; Zombaria, Portugal, January 1879, H. Moeller 275. By courtesy of Dr Fernandès, Director of Coimbra Botanic Garden, it has been my privilege to study the type material of this species. My observations confirm those of Guba (*Mycologia*, **24**, 375, 1932) save in one or two minor respects; the acervuli are $\pm 300\mu$ in diameter and the conidia are broader, $7-8\mu$. The acervuli are intermixed with pycnidia of a *Phomale*, about 150μ diam., which can easily be mistaken for the *Pestalotiopsis* under the binocular or the low power of a microscope (Fig. 3a).

On the same leaves I was fortunate enough to discover a second *Pestalotiopsis* (see *P. gigas* p. 86).

(b) On withered leaves of *Theobroma cacao* L. seedlings, associated with *Cercospora* sp.; Sungai Klah Estate, Perak, Malaya; 5 October 1948; A. Johnston (Herb. Div. Pl. Path. Malaya 226) (BR.) (I.M.I. 33513).

Macules indefinite involving the whole leaf. *Acervuli* scattered over the whole leaf in small groups, small, $50-100\mu$ in diameter, punctiform round, exuding conidia in small black masses. *Conidia* fusiform, 4-septate, $19-21-25\mu \times 6-6.6-8\mu$; coloured cells $11-14.2-17\mu$ long, light yellowish fuliginous brown, the two upper cells a shade darker; end cells hyaline, apical short conical bearing a crest of 2-3 fine, spreading setulae, $9-15.8-22\mu$ long, the basal tapering into a pedicel $0.4-7\mu$ long (Fig. 3b).

(c) Culture ex Centraalbureau voor Schimmelcultures, Baarn, on beer wort plus salep, isolated from *Delonix regia* (Boj.) Rafin., Philippine Islands, leg. Reyes, comm. R. O. Ocfemia, determ. H. W. Wollenweber (2820) (Wollenweber, H. W. and Hochapfel, H., in *Z. PflKrankh.* **46**, 401, 1936; sub *Pestalotiopsis cruenta* (Syd.) Steyaert in *Bull. Jard. bot. Brux.* **19**, 318, 1949.)

I have not seen Sydow's type specimen of *Pestalotia cruenta*, but his description of this species is not very different from that of *Pestalotiopsis neglecta* of which I have seen the type specimen. It is possible therefore that *Pestalotiopsis cruenta* is a synonym of *P. neglecta*.

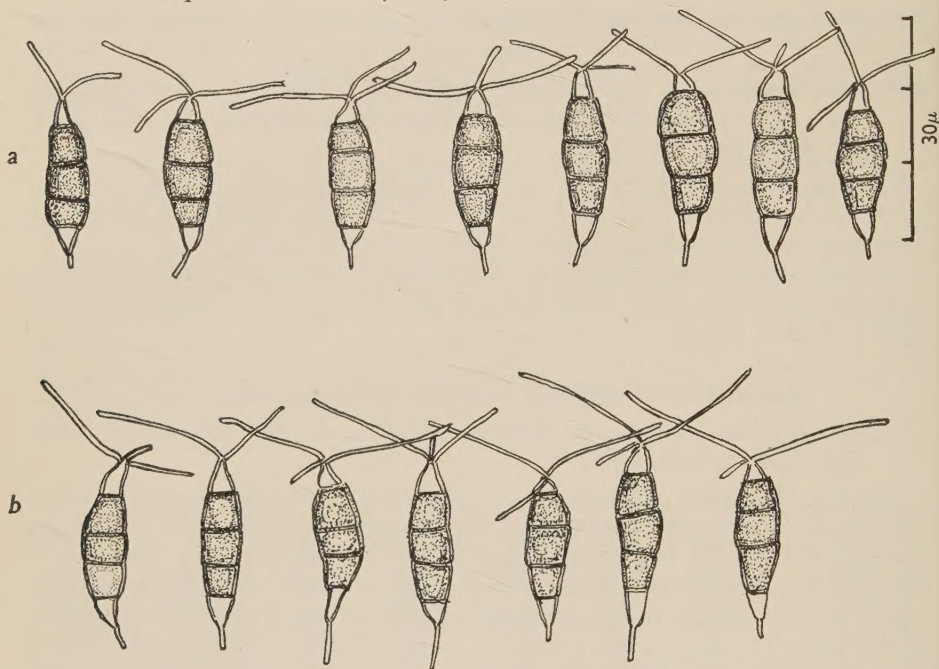


Fig. 3. Conidia of *P. neglecta*. (a, from H. Möller 275; b, from Malaya, A. Johnston.) ($\times 1000$.)

Pestalotiopsis disseminata (Thuem.) Steyaert, in *Bull. Jard. bot. Brux.* **19**, 319, 1949

Pestalotia disseminata Thuem., in *Instituto, Coimbra*, **18**, 501, 1880; Sacc. *Syll. Fung.* **3**, 784, 1884; Guba in *Mycologia*, **24**, 365, 1932.

The culture on oat agar shows a dense white felty growth covering the medium, with sparse thick immersed acervuli.

Conidia fusiform, 4-septate, $18-25.6-29\mu \times 7-7.3-8\mu$; coloured cells concolorous but the two upper a shade darker than the lower; end cells conoid, the apical bearing a crest of 2-3 fine setulae $13-17.3-23\mu$, the basal tapering into a pedicel $4-4.6-6\mu$ long.

Culture on oat agar, isolated from senescent fruit stalks of *Aleurites montana* Wilson, Nyasaland; P. O. Wiehe (BR.) (I.M.I. 43973).

Pestalotiopsis royenae (Guba) Steyaert, in *Bull. Jard. bot. Brux.* **19**, 320, 1949

Pestalotia royenae Guba, in *Mycologia*, **14**, 380, 1932.

Culture on Dox agar producing a thin cottony overgrowth with numerous black conidial masses. *Conidia* long fusiform $(17)20-23.5-28\mu \times 5-6-7\mu$; coloured cells concolorous, of a very light virescent olivaceous brown, lower cell or sometimes the middle one with a small gutta; end cells long conoid, hyaline, the apical bearing a crest of 2-3-4 setulae $5-11.2-17(22)\mu$ long, the lower tapering into a pedicel $2-4.3-7\mu$ long.

Culture on Dox agar, isolated by Dr Maria de Lourdes de Oliveira from *Phormium tenax*, Açores, Portugal.

Subgroup: Spathulatae

Pestalotiopsis theae (Saw.) Steyaert var. **minor** (Steyaert) Steyaert, in *Bull. Jard. bot. Brux.* **19**, 327, 1949

Pestalotia theae Saw. var. *minor* Steyaert, in *Bull. Jard. bot. Brux.* **19**, 184, 1948.

Conidia long fusiform, constricted at the septa, $26-27.6-31\mu \times 6.5-7.1-8\mu$; coloured cells pale brown, guttulate, $18-19.7-21\mu$ long; setulae 3, spathulate, spreading, $15-20.5-29\mu$ long; pedicel $3-4-6\mu$ long.

Though of the same length as those of the type variety the conidia are narrower and with shorter setulae.

Isolated from artificially induced lesions on *Theobroma cacao* L., cultured on malt agar; Tafo, Gold Coast Colony, 21 June 1949; H. Owen 732 (BR.) (I.M.I. 40651).

Pestalotiopsis papposa Steyaert, in *Bull. Jard. bot. Brux.* **19**, 325, 1949

Conidia fusiform, slightly constricted at septa, $20-23.1-26\mu \times (5)6-6.7-8\mu$; coloured cells pale brown, finely guttulate; setulae 3 rarely 2, spathulate, spreading, $12-16-23\mu$; pedicel $2-4.4-6\mu$.

Isolated from artificially induced lesions on *Theobroma cacao* L., cultured on potato-carrot agar and oat agar; Tafo, Gold Coast Colony, 13 December 1949; H. Owen, 701 (BR.) (I.M.I. 40644).

Subsection: VERSICOLORES. Group: Claviformes

Pestalotiopsis virgatula (Kleb.) Steyaert, in *Bull. Jard. bot. Brux.* **19**, 336, 1949

Pestalotia virgatula Kleb., in *Mykol. Zbl.* **4**, 13, 1914; Sacc. *Syll. Fung.* **25**, 599, 1931.

Conidia claviform, $18-20.5-23\mu \times 7.5-8.25-9\mu$; coloured cells versicoloured, the two upper dark fuliginous, the lower light brown, $13-14.3-17\mu$; apical cell short conoid bearing a crest of 2-3 sometimes 4 spreading setulae $16-21-26(28)\mu$ long, the basal short conoid or sometimes hemispherical tapering into a pedicel $3-3.8-6\mu$ long.

Isolated from *Citrus aurantium* L.; cultured on Dodge agar; New Caledonia, 15 January 1951; F. Bugnicourt (BR.).

The same species was also received in culture on Czapek agar on which growth was very slow and the conidia poorly developed.

Pestalotiopsis versicolor (Speg.) Steyaert, in *Bull. Jard. bot. Brux.* **19**, 336, 1949

Pestalotia versicolor Speg. in *Michelia*, **1**, 479, 1879; Sacc. *Syll. Fung.* **3**, 790, 1884; Guba in *Phytopathology*, **19**, 222, 1929, descr. em.

Conidia claviform, straight or sometimes slightly curved, $18-22.6-27\mu \times 6.5-7.8-10\mu$; coloured cells versicoloured, the two upper each with a large gutta, the middle cell dark fuliginous, opaque, the lower pale and the upper intermediate in colour, $12-15.7-19\mu$ long; end cells hyaline, the apical bearing a crest of 2-3, rarely 4, spreading setulae, $12-19.6-30(33)\mu$ long, the basal usually conoid tapering to a pedicel $2-4.3-8\mu$ long.

Isolated from the wood of senescent fruit stalks of *Aleurites montana* Wilson; Nyasaland, cultured on malt agar; P. O. Wiehe 776(8)a (BR.) (I.M.I. 43972); P. O. Wiehe 803(2)d (BR.) (I.M.I. 43974).

Isolated from artificially induced lesions on *Theobroma cacao* L.; Tafo, Gold Coast Colony; H. Owen 700, 26 July 1949, cultured on malt agar (BR.) (I.M.I. 40643); H. Owen, 723, 14 January 1947, cultured on oat agar and potato-carrot agar (BR.) (I.M.I. 40649); H. Owen 733, 21 July 1949, cultured on oat agar (BR.) (I.M.I. 40652).

Pestalotiopsis glandicola (Cast.) Steyaert, in *Bull. Jard. bot. Brux.* **19**, 330, 1949

Pestalotia glandicola (Cast.) Guba, in *Phytopathology*, **19**, 206, 1929.

Conidia claviform, $22-24.1-27\mu \times 7-9-11\mu$; coloured cells versicoloured, the two upper dark fuliginous brown, the lower light brown; end cells hyaline the apical short conoid bearing a crest of 2-3-4 spreading setulae, $13-25.5-38\mu$ long, the basal cell short conoid tapering to a pedicel $4-5.7-8\mu$ long.

Isolated from twigs of *Mangifera indica* L.; Chemilil, Kenya; R. M. Natrass 1293 (BR.) (I.M.I. 38808).

Pestalotiopsis gigas Steyaert sp. nov.

Conidia claviformia vel late fusiformia, recta, 4-septata, $31-34.1-37\mu \times 9-10.1-11\mu$; cellulae 3 mediae versicolores brunneo-olivacea fuliginosae, guttatae, $21-24.8-26\mu$; cellulae extimae hyalinae late conoides vel leniter rotundatae, apicalis 2-3 setulas patulas, crassas, interdumve spathulas, $20-30.7-40\mu$ gerens, basalis in pedicello crasso, $5-7-10\mu$ desinens (Fig. 4).

Isolated from tea (*Thea sinensis*) leaf, cultured on potato-carrot agar; Kericho, Kenya; R. M. Natrass 1289 (BR. holotype) (I.M.I. 38806).

On *Euonymus japonicus* L., Zombaria, Portugal, January 1879; in association with *Pestalotiopsis neglecta* (Thuem.) Steyaert; H. Moeller 275 (C.).

In culture the mycelium is closely appressed to the medium with

pinhead size masses of conidia more or less regularly dispersed over the surface. A refringent globular mass is observable in each of the coloured cells of which the two upper are darker. The setulae are thick with an easily visible lumen.

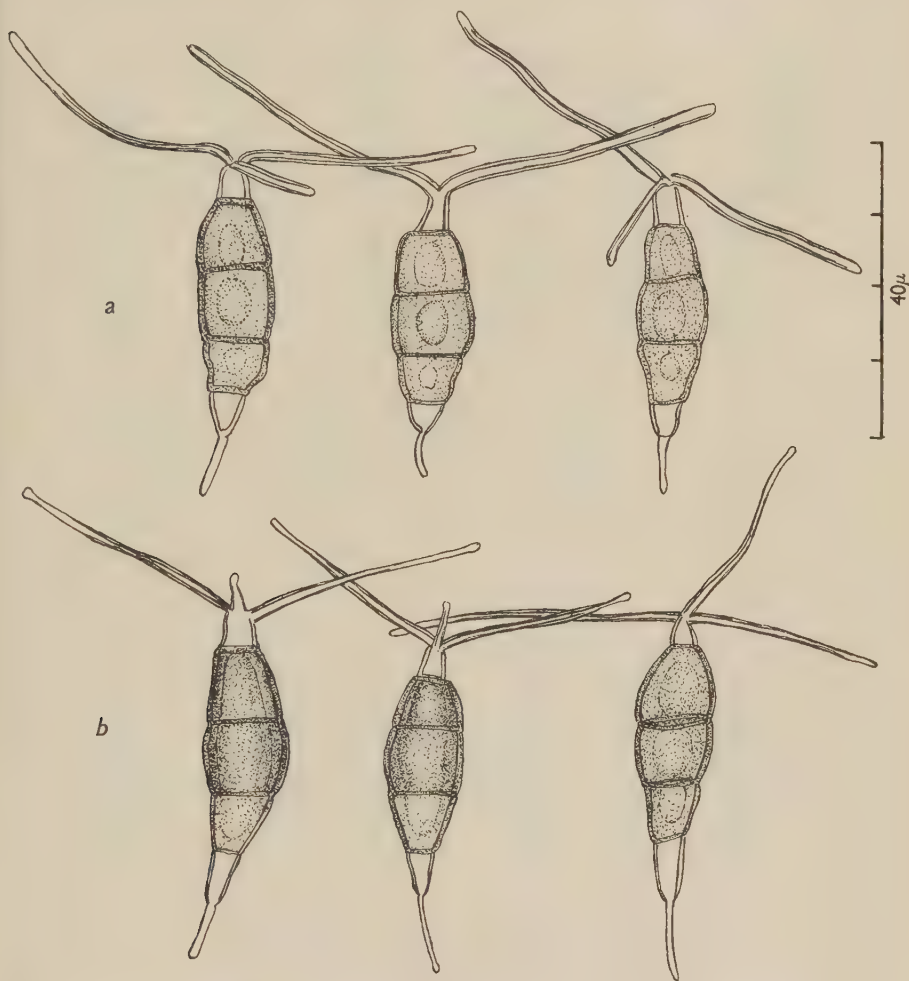


Fig. 4. Conidia of *P. gigas*. (a, from R. M. Nattrass 1289; b, from H. Möller 275.) ($\times 1000$.)

Section: MULTISETULATAE.

Subsection: CONOCOLORES subsect. nov.: cellulae 3 media conidiorum concolores

Pestalotiopsis funerioides Steyaert, in *Bull. Jard. bot. Brux.* **19**, 345, 1949.

Conidia fusiform, $26-29.1-32\mu \times 7-8-9\mu$; median cells concolorous, light umber, guttulate, $18-20-22\mu$ long; apical cell long conoid, bearing 3 to 5 setulae, one erect the others spreading, $10-17.3-23(28)\mu$ long, the basal tapering to a pedicel $5-7.5-11\mu$ long.

On cones of *Cupressus* sp.; Westdean plantations, Friston, Sussex, England; P. K. C. Austwick, 10 February 1950 (BR.) (I.M.I. 40068).

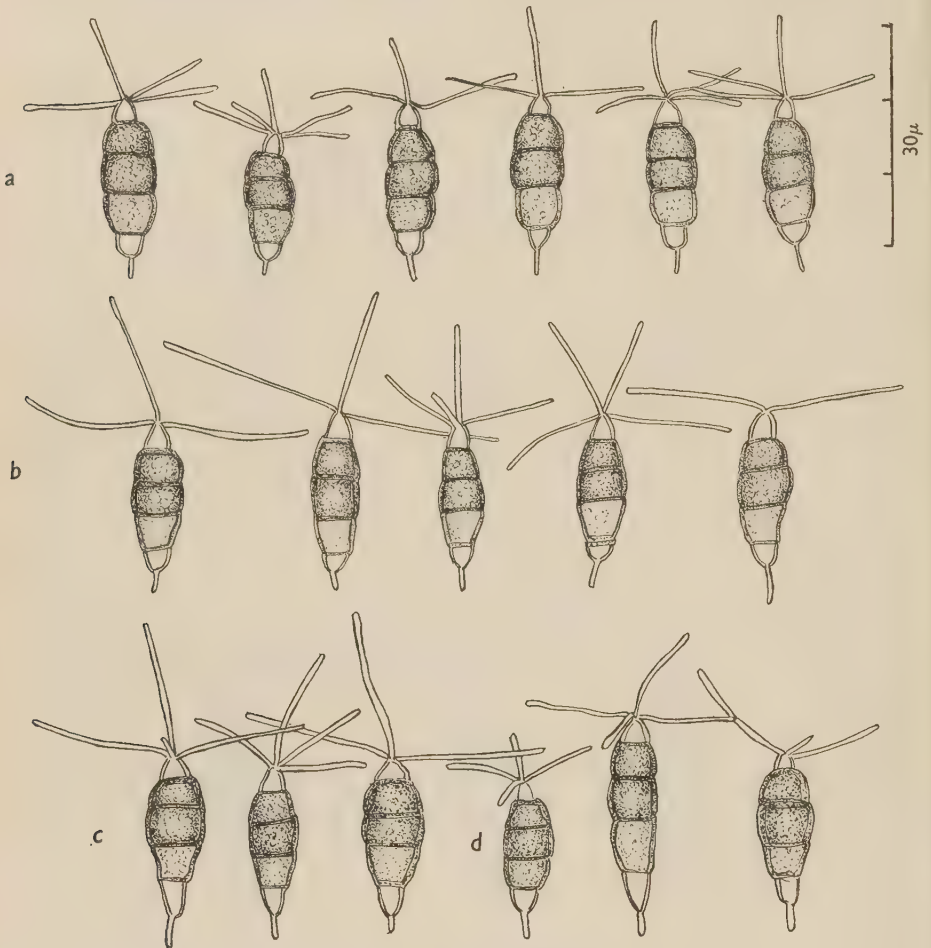


Fig. 5. Conidia of *P. owenii*. (*a*, from H. Owen 702 cultured on malt agar, holotype; *b*, from H. Owen 702 cultured on oat agar; *c*, from H. Owen 703 cultured on oat agar; *d*, from H. Owen 703 cultured on potato-carrot agar.) ($\times 1000$.)

Subsection: **VERSICOLORES** subsect. nov.
cellulae 3 mediae condiorum versicolores

***Pestalotiopsis owenii* Steyaert sp. nov.**

Conidia claviformia, 4-septate, $17-20.9-26(29) \mu \times 5.5-7.1-9 \mu$; cellulae 3 mediae versicolores, 2 superiore umbrinae, inferiore olivacea; cellulae extimae hyalinae, apicalis conoides (2) 3-4-5 setulae $9-15.6-25 \mu$, 1 erecta etcetera patulas, gerens, basalis in pedicello $2-3.5-6 \mu$ desinens (Fig. 5).

Isolated from artificially induced lesions on *Theobroma cacao* L.; Tafo, Gold Coast Colony, 14 October 1949; cultured on malt agar, H. Owen,

702 (BR. holotype) (I.M.I. 40645*b*); on oat agar (BR.) (I.M.I. 40645*b*); on oat agar 28 May 1949, H. Owen 703 (BR.) (I.M.I. 40646); on potato-carrot agar (BR.) (I.M.I. 40646*a*).

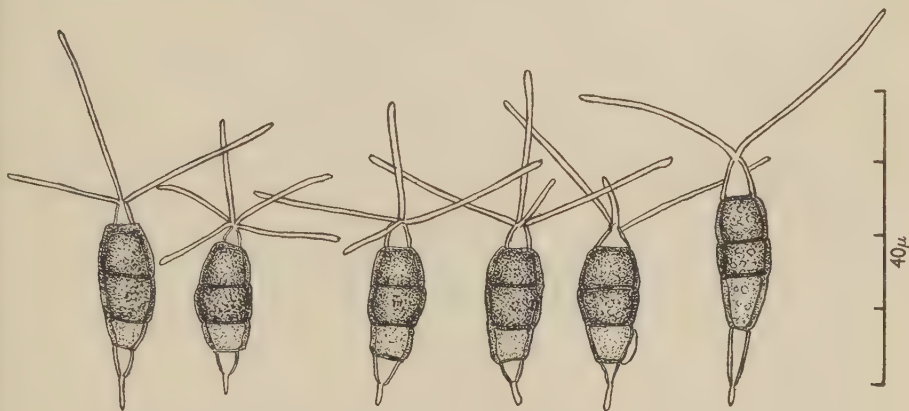


Fig. 6. Conidia of *P. owenii* var. *major*. (From H. Owen 702, culture on malt agar—sector with acervuli grouped in dense concentric rings.) ($\times 1000$.)

var. **major** Steyaert var. nov.

Conidia majora quam ea varietatis typicae, $20-23-26 \mu \times 7-7.6-8 \mu$; cellulae 3 mediae $12-13.9-16(20) \mu$ longo; setulae $15-22-29 \mu$ longo (Fig. 6).

Isolated from artificially induced lesions on *Theobroma cacao* L.; Tafo, Gold Coast Colony; cultured on malt agar, H. Owen 702 (BR.) (I.M.I. 40645*a*, sector with acervuli grouped in dense concentric rings).

The variety originated as a sector of the type variety culture; besides having somewhat larger conidia and distinctly larger setulae its acervuli are disposed in dense concentric rings, whereas in the type variety the acervuli are more or less diffuse and loosely dispersed over the surface of the medium.

Mr S. J. Hughes has kindly prepared this paper for publication. I am grateful for his courtesy.

(Accepted for publication 15 March 1952)

FIELD VARIATION IN *VENTURIA PIRINA*

BY W. R. STANTON

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(With Plate 5 and 5 Text-figures)

The variation of eighty isolates of the pear scab fungus, *Venturia pirina* Aderh., collected from various parts of England and from different pear varieties has been studied in culture.

No correlation has been found between the different types and the host varieties from which they originated. This lack of correlation is attributed to the fact that isolates differing widely in morphology and nutritional requirements can be obtained from individual hosts. Neither did the variation appear to be clearly related to geography as in Germany.

INTRODUCTION

The discovery of segregation in the ascus of *Neurospora* by Dodge (1927) opened a new field of mycological research, and the application of this work to *Venturia inaequalis* by Keitt and Palmiter (1938) and Keitt and Langford (1941) and to *V. pirina* by Langford and Keitt (1942) has increased our knowledge of the genetic behaviour of these fungi. Recently, Boone (1951 and unpublished) has advanced this work still further by his mapping the four linkage groups in *V. inaequalis*.

Variation in *Venturia* has been extensively studied by a number of German and Swiss workers (Wiesmann, 1931; Rudloff, 1934*b*; Schmidt, 1935, 1936*a*, 1936*b*; Herbst, 1936). This early work is in general obscure, as it is difficult to relate the morphotypes described to experimentally demonstrated gene expressions. They concluded that variability was enormous and that the number of morphotypes was a function of the number of samples collected. Differences existed even between isolates from a single leaf (Schmidt, 1935). However, from the very large number of isolations made they were able to demonstrate a north-west to south-east clonal drift across Germany. That is, isolates in a particular district could often be related to others which had been found to be common in a district along the same north-west to south-east axis but not to those in other directions. This axis corresponds to the prevailing wind direction.

This paper describes some of the variants found in cultures of *V. pirina* Aderh. from collections made in various parts of England. Variation has been studied for its significance for epidemiology and for the problem of biotype variation.

MATERIALS AND METHODS

Isolation. The ascospores, conidiospores and mycelium of *V. pirina* are monokaryotic, and it is thus possible to obtain monokaryotic clones of the fungus by culturing units of any of them. In practice, however, methods of isolation are limited by the saprophytic microflora on the host. This

* Now at Maize Rust Unit, Department of Agriculture, Ibadan, Nigeria.

consists principally of a variety of bacteria and yeasts, but viable spores of a number of saprophytic fungi are found on field lesions.

The simplest method of isolation is to discharge perithecia on moistened dead leaves. The spores, which are shot off to a height of 0.5 cm., are trapped on an agared slide, from whence they may be removed uncontaminated. Ascus segregation may be demonstrated by culturing, separately, the spores shot from a single perithecium. Some of the first segregates were obtained in this way. When improved equipment was available ascus dissection was employed to study morphological segregation.

As a method of sampling the population, as found on the trees, the isolation from perithecia is unsatisfactory, in that perithecial isolates are recombinants of the original lesion-producing genotypes. Both conidial and ascosporal isolates have therefore been used in these studies, the use of ascosporal isolates being confined to the problem of genetic determination of cultural characteristics.

Single conidia were isolated as follows. From a sterile glass tube with a fine tip, a drop of sterile water was exuded on to a young scab lesion for preference or alternatively on to the margin of an old lesion. The wetted part of the lesion was very lightly rubbed with the tip of the tube and the water sucked back into the tube after half a minute. This drop was then spread on a slide which had previously been covered with a 2 mm. layer of nutrient agar and the slide was incubated at 18° C. for 24 hr. in a moist chamber. Single germinating conidia were then picked off with a tungsten needle using a binocular dissecting microscope. Tungsten needles are superior to glass for this work. Their manufacture and use are described by Cannon (1941) and Harding and Washtell (1950). Agared slides are considered superior to Petri dishes for making large numbers of isolations and are easier to manipulate under the dissecting microscope. The moist chamber consisted of an aluminium flanged tray with a glass top and a layer of moistened filter-paper inside. The materials for this chamber are easily sterilized separately (the glass and metal by alcohol) before use.

Differentiation and classification of isolates. Samples were examined from most of the pear-growing districts, and from each original single spore culture a series of five single-spore cultures were made on yeast agar. After growing for 14 days at 18° C., two were preserved under mineral oil (Wernham, 1946; Wernham & Miller, 1948) and stored in a refrigerator at 5° C. Five subcultures were used to check that the original cultures were not giving rise to a proportion of morphologically mutant spores. At the same time three spores were planted on Dox agar on a 10 cm. Petri dish, for detailed morphological study.

Morphological variation is greatly affected in this fungus, as in many others, by the medium on which it is grown. Malt agar, for a long time the classic medium for culturing *Venturia*, has the defects of variation in the raw material and in its preparation as an agar (Miller, 1949). This variation produces variation in the growth rate and appearance of cultures. The more stable crystalline malts tend to be less satisfactory in supplying nutrients to the fungus.

Nutrient requirement and growth inhibitors for *Venturia* species have been investigated in detail by Rudloff (1934*a, b*), Leben and Keitt (1948)

and Kirkham (unpublished). For *V. pirina*, yeast agar (0.25% Difco Yeast Extract added to Dox agar) satisfied the nutrient requirements of the wide range of naturally occurring variants studied. Dox agar, on the other hand, is a useful medium, some spores growing weakly and others vigorously, and in this way differentiation of a population can be determined on a basis of nutritional requirement.

The single-spore isolates in Petri dishes were grown for 30 days at 18° C. and then described and measured. Pl. 5*a*, *b* and *c* shows three replicate single-spore cultures from three different clones, and the detail of the margin of a fourth clone (*d*). Pl. 5*a* differs from *b* in colony margin, and this difference is shown in greater detail in *e* and *g*. Pl. 5*c* shows a clone which produces a very stunted colony on Dox agar, the appearance of which is shown in greater detail in *h*. Pl. 5*d* shows a mutation in growth rate of a smooth margined colony tested by hyphal tip isolations from this sector, and *f* shows a sparse type of growth compared with the dense type exhibited in *e* and *g*.

Method of description. Pl. 5 shows that the difference in appearance between clones is large compared with the variation shown by replicate colonies of a particular clone. This within-clone variation is shown in Pl. 5*a*, where there are differences in the density of growth of the three colonies. Such differences are not, however, permanent. This non-heritable fluctuation has been observed by Keitt and Langford (1941).

I assessed heritable variation from ascospores isolated in serial order. The method used was similar to that described by Keitt and Langford (1941) and Shay and Keitt (1945), between eight and twelve asci being dissected from each of the available artificial matings. The results of *in vitro* matings have, to date, proved unsatisfactory. Some matings produced fertile perithecia, but the majority of the known compatible matings failed to mature their perithecia. For this reason detailed studies of linkage between characters were not possible.

Replicate cultures obtained from the ascospores were planted on Petri dishes and the colonies given an initial description. From comparing the descriptions, and noting where differences coincided with suspected differences in the original sets of eight ascospores, the character differences shown in Table 1 were adopted.

A colony viewed from above, which is carrying the matrical character **a**, appears surrounded by a wide black corona due to the submerged hyphae advancing well in front of the aerial hyphae. Undulate mycelium, **s**, is illustrated in Pl. 5*e*. Colour in the aerial hyphae varies from a dark brown through a series of intermediate browns and greys to ivory. The difference between coloured and ivory is distinct, but the subdivisions of coloured fall into three types, 'Dark Brown' **Br G**, 'Brown' **Br g** and 'Grey' **br G**, is a deliberate simplification, the limitation of which must be clearly recognized.

In Text-fig. 1 are indicated the positions on Petri dish colonies where the various features may be seen.

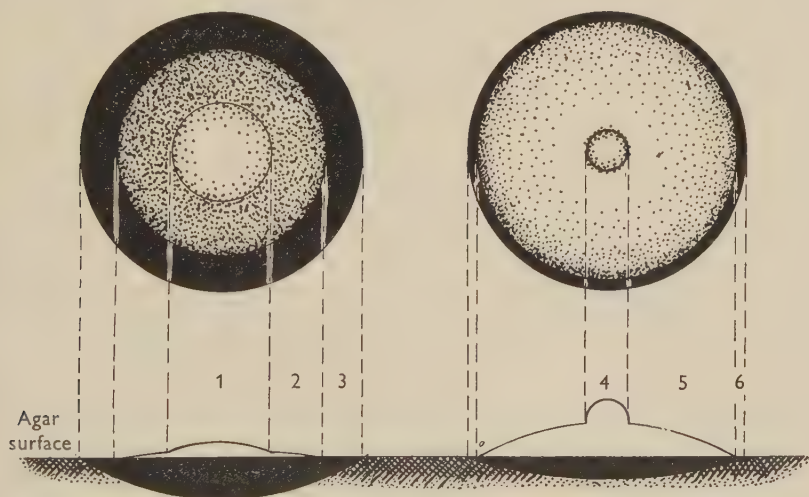
The left-hand diagram shows a matrical colony without a boss and the right-hand diagram an aerial bossed colony. Note that in the transverse sections the mycelium in the matrical type ramifies more deeply and

constitutes the bulk of the colony. Colony colour is taken from zones 1 and 5 respectively.

Size differences can be shown by the fungus in two ways: first, on a complete medium and, secondly, on a medium such as Dox. Differences exhibited by the eight spores when grown on Dox may be eliminated by

Table 1. Summary of character differences which appear from ascus dissection to be under single-gene control

		Gene		Allele
Mycelial growth	Aerial	A	Matrical	a
Mycelial growth	Dense	D	Sparse	d
Mycelial hyphae	Straight	S	Undulate	s
Mycelium coloured (aerial)		Br-G		
		Br-g	Ivory	br-g
		br-G		
Colony (on a complete medium)	Large	L	Small	l
Colony (on a complete medium)	Margin regular	R	Irregular	r
Colony (on a complete medium)	Bossed	B	Without boss	b
Physiological differences				
Thiamin requiring		V_{B₁}	Thiamin not essential	v_{B₁}



Text-fig. 1. *Venturia pirina*. Features of colony form in Petri dish culture. 1, 5, zones of aerial mycelium; 2, wide zone of very sparse aerial mycelium bearing conidiophores; 3, wide zone of completely submerged mycelium; 4, position and relative size of boss; 6, narrow zone of submerged mycelium.

growing the fungus on a complete medium or by the addition of thiamin to the Dox medium. On the other hand, a residual size difference has shown itself between colonies grown from ascospores on a complete medium. The two have been therefore distinguished by different symbols.

In addition to morphological characters, growth rate and conidium size have been used in the description of isolates. Other workers have also used conidia production (Keitt, Langford & Shay, 1948; Kirkham,

unpublished), but this statistic would appear more useful for *inaequalis* than *pirina*; the differentiation into 'high conidia producing', 'low conidia producing' and non-conidial being apparently less discrete in the range of isolates used in these studies. In the use of conidia production as a measure of nutritional requirement Kirkham has found this fungus less manageable than *inaequalis*. The use of growth rate in studies of the interaction of fungus and substrate has been discussed at length by Emerson and Cushing (1946), working with *Neurospora*, and also by Hawker (1950). They analyse the apparent sigmoid growth curves produced by tube cultures into three characteristic phases, a lag phase, a linear growth phase, and a falling-off of growth phase. They further show how a change in the slope of the linear growth phase reflects a change in response to the substrate. This method of analysing the growth response of *Venturia* to the medium has been applied in the experiment described below (p. 98).

RESULTS

Type frequency in the population

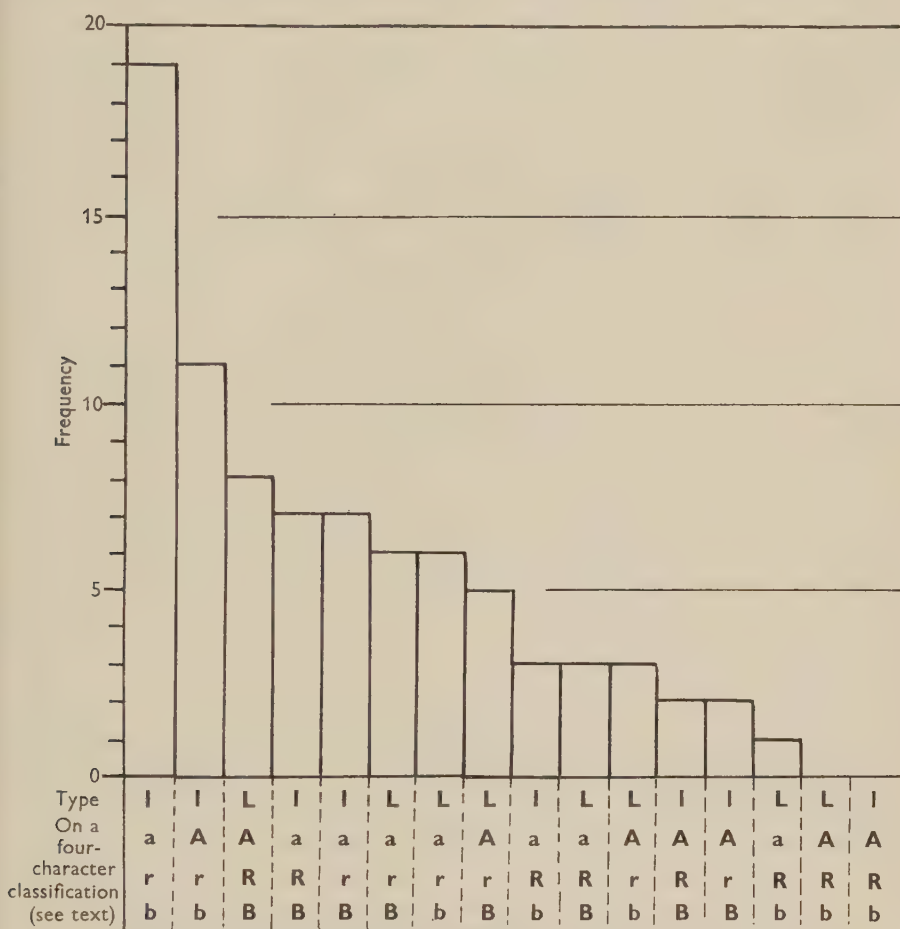
I examined eighty samples of fruit and leaves for these investigations covering the variation between trees, varieties and localities. While this population sample yielded much useful material for a basis for a culture collection, it was found, as had been the experience of earlier workers, that morphological variation was too great to allow a detailed analysis. Each isolate was described, replicates being discarded, and its growth rate measured and nutritional requirements classified by growing on Dox agar.

Some types appeared to be commoner than others, and this is shown by Text-fig. 2, which was obtained by grouping the isolates from the different samples on the basis of the four, previously described colony characters; size **L** or **l**, habit **A** (aerial) or **a**, colony margin **R** (Regular) or **r**, and presence or absence of boss on the colony **B** or **b** respectively. Thus there could be sixteen possible types and, of these, fourteen were found. The fifteenth, '**LARb**', was found only in culture and the sixteenth not at all. It is concluded from this that the morphology of an isolate affects its success as a pathogen. If the four characters are considered separately, then the characters **l**, **a**, **r** and **B** seem to be represented more frequently in the population than their alleles **L**, **A**, **R** and **b**.

A further analysis of these types in regions and varieties showed no significant geographical or varietal correlations. To test the possibility that morphotype differences might yet be of value in population analysis, where the variation was limited, a large sample was collected from two adjacent trees growing in a walled garden at Bayfordbury.

Samples of scab-infected fruit and adjacent leaves were taken from mid-branch and tip positions of all the main framework branches of both trees, one of which was a Beurré Diel and the other a Doyenné du Comice. They were 35-year-old trees pruned in the form of a cup or 'open centre', and were situated near the middle of the garden some 4 m. apart. This source gave twenty-four 'position' samples, each consisting of one or more fruits, scabbed leaves, or both. Five contaminant-free isolates were obtained from each fruit and leaf lesion. The morphotypes were then classified and

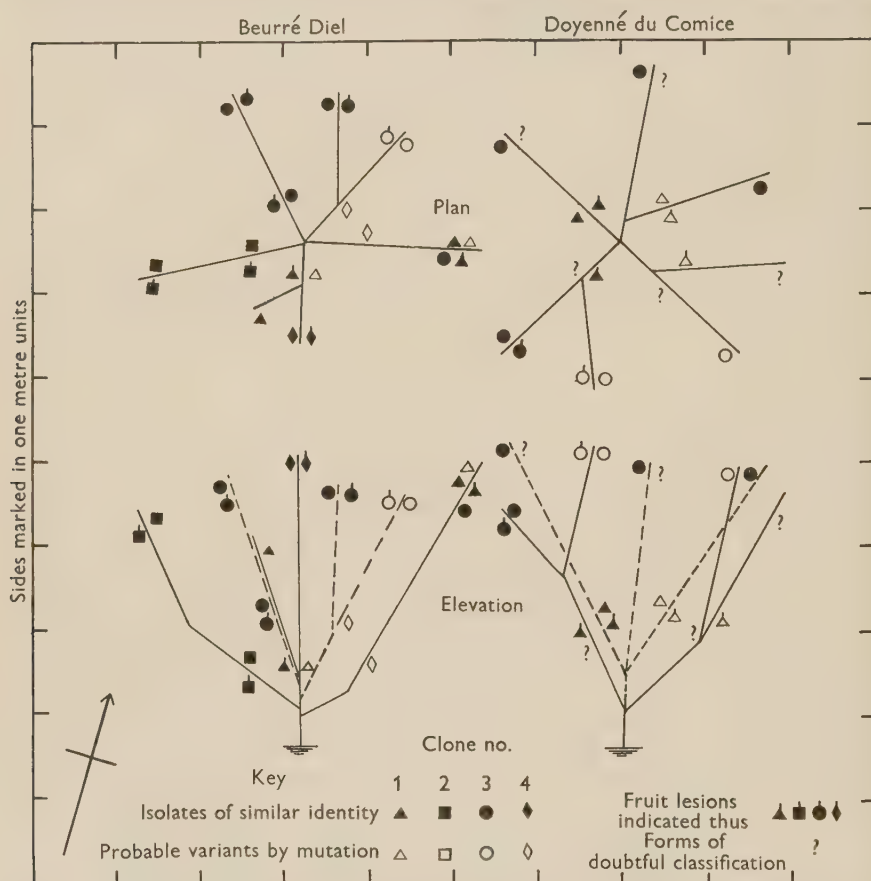
the results of this classification are shown in Text-fig. 3. The isolates were grouped into those of similar morphotype and four major groups were found to be present. These four groups are indicated by the symbols on the diagram. Within the groups a number of the isolates were found to be identical, and these are indicated by the solid symbols. Hollow symbols



Text-fig. 2. *Venturia pirina*. Variation in morphology of the field population. Isolates in the collection were classified on the basis of the four characters: size **L** or **l**, habit **A** or **a** (relative growth of mycelium above and below the agar surface), colony margin **R** or **r**, colony profile **B** or **b**. Replicate isolates from a sample were not used. For a detailed description of these characters see text. The frequency number is the number of isolates of the type from different samples.

indicate the isolates that were recognizably members of the group but differed from the type in some slight degree. Classification was done with reference to the Beurré Diel population, as there seemed to be less variation on this variety, and it was also the more heavily attacked. Samples which could not be included in this grouping are indicated by a question mark.

It will be seen from Text-fig. 3 that fruit and leaf lesions from the same branch position carried the same morphotype. Further, the same morphotype tended to occupy top and mid positions on the branch, and similar



Text-fig. 3. Morphotype differences of *Venturia pirina* on two adjacent trees; description of the four clones mapped above:

	Habit	Margin	Boss	Colour
Clone 1	a	r	b	Brown-grey Br G
Clone 2	a	R	b	Neutral-grey br G
Clone 3	a	R	B	Neutral-grey br G
Clone 4	a	r	b	Brown-grey Br G

Habit. Aerial **A** or matrical **a**.

Margin. Regular **R** or irregular **r**.

Boss. Large **B** or small to absent **b**.

Colour. Approximate description only.

positions on adjacent branches bore the same types. Types found on the Beurré Diel tree were present on the Comice tree, though this tree was not so heavily parasitized, and then by only two of the Beurré Diel clones. Several other types were present which were not represented on the Beurré Diel.

Extremely limited variation was found on a Glou Morceau tree in the same garden. This tree was sampled several times during the summers of 1949 and 1950, from different parts of the tree, and all the isolations were identical. These trees had received no spraying for several years before the investigation.

Significance of differences in growth rate

The four clones from the Beurré Diel experiment were further analysed for their differences in growth rate on yeast and Dox agars (Text-fig. 4).

Germinated spores were planted on 10 cm. Petri dishes containing Dox and yeast agar respectively. Three spores were used per Petri dish and two Petri dishes per strain per medium. Colony size at 6-day intervals was measured in two directions by the use of an eyepiece micrometer. As the colonies increased in size (second reading onward) a pointer in the eyepiece was focused on the colony margin, and the reading taken off the verniers of the mechanical stage. Measurements were continued for 30 days.

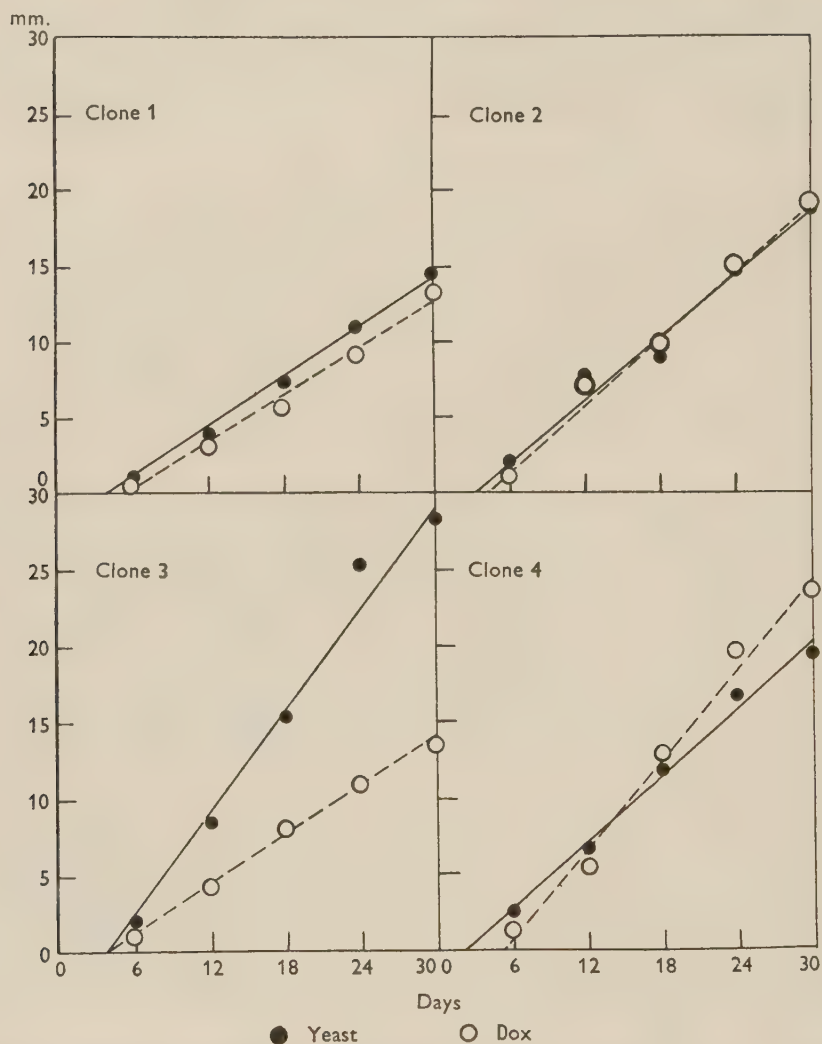
After 30 days, growth fell off because the Petri dish no longer presented an unlimited plane of medium for growth. The full-growth curve would therefore have presented the false sigmoid (see p. 94). The reason for an initial *variable* lag period is not quite clear, but it seems in part a transplanting shock. It is certainly not due to a permanent change, as the identical lag pattern is repeated at successive transplantings. The form of growth curves in micro-organisms is discussed by Paul (1929), McIlwain (1946), and Emerson and Cushing (1946). In calculating the regression lines, the '0, 0' value is omitted and the slope of the line gives a true reading of the stabilized linear growth rate, since the first measurement taken is after the lag period.

From these regression lines may be deduced that: (1) clones 3 and 4 differ in their growth rate on the two media; (2) clones 1 and 4 differ in the lag period on the two media; and (3) clone 2 is not affected, differentially, in growth response to the two media. This method of presenting clonal differences appears therefore to be of value in analysing the growth response of *Venturia* to particular substrates. In particular, it seems applicable for studying response to toxic substances in the medium and for measuring changes in that response.

Variations in colony diameter and conidiospore size on a complete medium

Finally, I investigated the variation in colony diameter on a complete medium (yeast agar), and also the variation in spore size. The colony diameter statistic was shown to be of value by Brown (1923).

The colonies were grown on yeast agar and measured after 30 days. The figures were grouped according to the original hosts of the isolates and the result presented in the form of histograms (Text-fig. 5). It will be seen that the modal diameters of the different varieties are similar, with the exception of that of the variety Williams. It appears that isolates occur on Glou Morceau, Durondeau and Williams which are beyond the range of Comice and Conference. For comparative purposes, the colony diameters of the collection of ascospore isolates have also been grouped,



Text-fig. 4. Development of single-spore cultures (as mean colony diameter at 6-day intervals).
●, yeast; ○, dox.

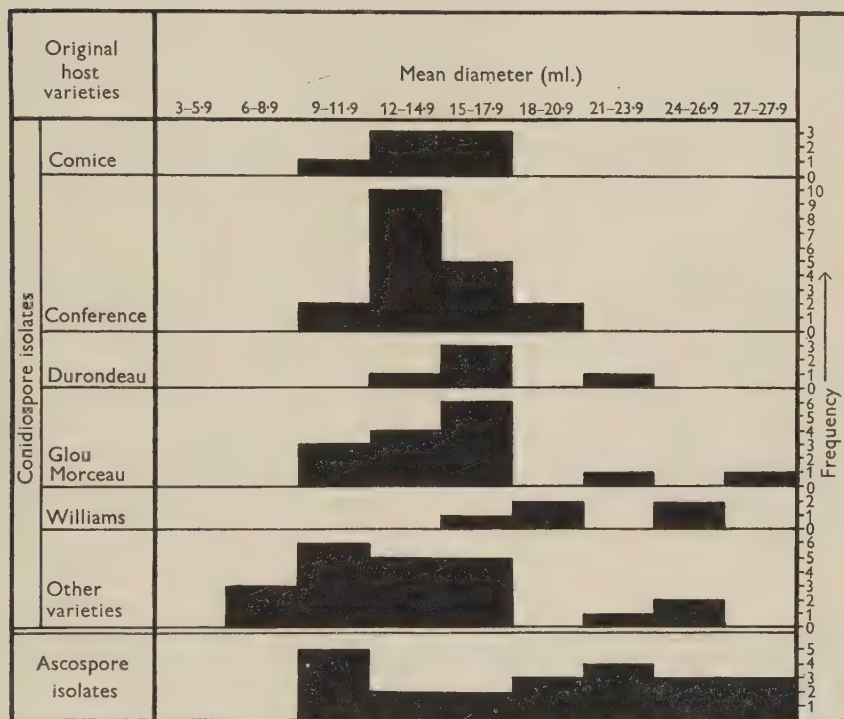
Regression equations of the lines shown in figure of growth rate on medium of four clones from the same tree.

Clone 1	Yeast	$y = 3.35 \pm 0.13x - 2.57 \pm 0.09$
	Dox	$y = 3.09 \pm 0.27x - 2.92 \pm 0.19$
Clone 2	Yeast	$y = 4.25 \pm 0.37x - 2.75 \pm 0.26$
	Dox	$y = 4.40 \pm 0.09x - 3.22 \pm 0.06$
Clone 3	Yeast	$y = 6.61 \pm 0.21x - 4.24 \pm 0.15$
	Dox	$y = 3.18 \pm 0.26x - 1.81 \pm 0.19$
Clone 4	Yeast	$y = 4.37 \pm 0.36x - 1.63 \pm 0.26$
	Dox	$y = 5.89 \pm 0.48x - 5.20 \pm 0.34$

The standard errors of slope (growth rate) and constant (the measure of the initial lag period) are given after their respective values.

and it is noteworthy that their frequency distribution has two modes. These results indicate that host varieties, or possibly susceptibility groups, may have an effect on the selection of strains of the fungus with different cultural properties. It also appears that the segregation which occurs in the ascus may give rise to spores which are not successful pathogens in that the ascospore mode at the larger colony diameter is not repeated as a conidiospore mode. Other workers (Voges, 1907; Ewert, 1910; Cheal & Dillon Weston, 1938) have stressed the importance of overwintering in the

Colony diameter variation in culture



Text-fig. 5. Mean of two measurements at right angles on each of three colonies. The colonies were grown on yeast agar at 18° C.

asexual stage as a means of perennation in *V. pirina*. The evidence in this figure suggests that the recombination, prior to ascus formation, may not be a desirable annual event from the point of view of the fungus. These observations also indicate one of the few recognizable differences in morphology due to a factor in the environment of the fungus.

Spore size has been used by a number of workers. It is a statistic easily obtained and in which error can be well controlled and therefore presents the possibility of exhibiting either geographical clines or host modes. It is of less use for the classification of isolates, as this requires the measurement of large samples (Christensen & Graham, 1934; Gäumann, 1950, p. 189 et seq.).

I have found no significant correlations of spore size with either varieties or regions using a sample of twenty-five spores per isolate, and it would appear necessary to use much larger samples to investigate this point further. More detailed analysis has been confined for the present to the four clones used in the experiment above (p. 97). This experiment was designed to test the true difference between spore size of the four clones, the error of measurements, and the effect of medium on spore size. For this purpose, the spores were obtained from cultures on liquid and solid yeast media. The cultures were 14 days old and had been grown at 18° C. Washed spores were mounted in lactophenol and a series of ten length measurements taken from two fields on each of two slides. This was repeated for each clone on each of the two media. The results are summarized in terms of clones and media in Table 2. The only significant differences were found between clones and media and their interaction.

Table 2. *The significance of spore size differences of four clones on liquid and solid yeast media*

Media, yeast-dextrose	Clones				Medium means
	1	2	3	4	
Liquid (on filter-paper)	22·63*	24·45	23·15	30·37	25·15
Solid (agar slopes)	21·61	22·35	22·63	27·77	23·59
Clone means	22·12	23·40	22·89	29·07	

* Mean length of spores from one clone on one medium. Standard error of this observation 0·14.

Errors due to 'fields' and 'replicate slides' were very small. It seems likely therefore, from these results, that the absence of a significant result in the previous experiment is not due to errors of the 'within-clone' variation of spore size.

DISCUSSION

The main contributions to our knowledge of *Venturia* species are from Germany and the United States, where the pattern of fruit growing differs in a number of respects from the pattern in England.

The whole scale of geographical variation is reduced in England. Isolation by distance is less, and regions of particular geographical type are small and intergrade. The smaller scale of the topography means that climatic variation patterns are more complex than in the two 'continental climate' areas. Superimposed on this is the insular climate which means that the trees and their parasites are not subjected to the continental extremes of climate.

These factors would be likely, *a priori*, to make variation patterns more subtle and make difficult the isolation of some climatic gradient on which to build a hypothesis for testing. Possibly the east-west increasing rainfall gradient and increasing insularity gradient might be expected to select a detectable difference in the pathogen. Certainly pear growing appears to be limited to areas of below 100 cm. of rain per annum, and this is due to the increased damage due to scab in higher rainfall areas. A comparable situation occurs for apple growing. However, relative to apple growing,

pear growing is concentrated in the south and east of the country in favour of higher summer temperatures. This differentiation is more marked on the Continent and still more marked in the U.S.A., where the distribution of pear growing is similar to that of peach growing and even extends south and east of it, using varieties derived in part from the Japanese pear *Pyrus serotina*. Varieties derived from this pear, unlike those derived from *P. communis*, require less than 900 hr. of winter cooling below 7.5°C ., which amount is limiting to the southern extension of peach culture (Magness & Traub, 1941).

From these considerations, it is therefore less likely that discrete geographical races of *Venturia* exist in this country, and any differences that do exist are likely to be difficult to detect. An analysis of the isolate variation used in these studies bears out this hypothesis, and this preliminary survey indicates that a much higher order of sampling would be required, possibly a population of 5000 isolates, in order to detect the presence of geographical differences (either in morphology, colony diameter, or spore size).

The sample used has, however, indicated the similarity between variants of *pirina* in England and *pirina* in Germany and the U.S.A. on the one hand and the similarity with *inaequalis* on the other. This great overlap in morphological characters between the two species contrasts with the complete differentiation between hosts and provides yet another example of the misplaced emphasis on morphological differentiation in pathogenic fungi.

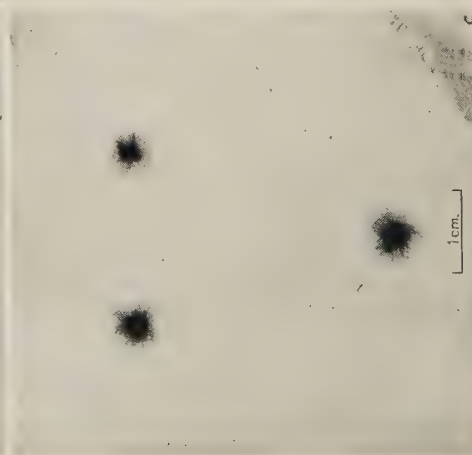
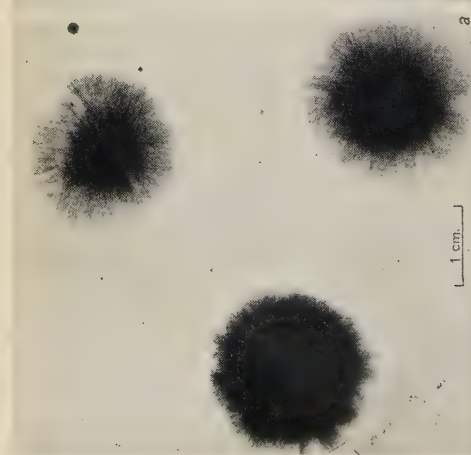
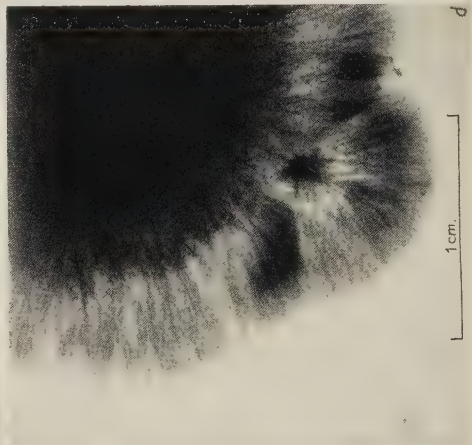
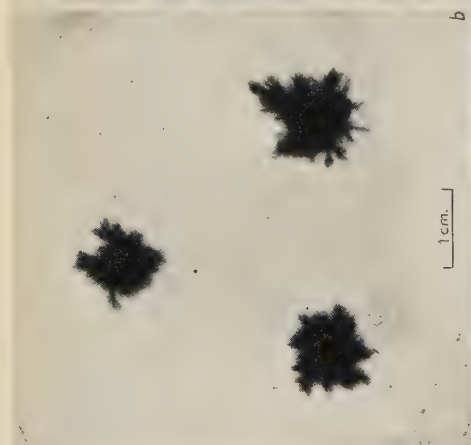
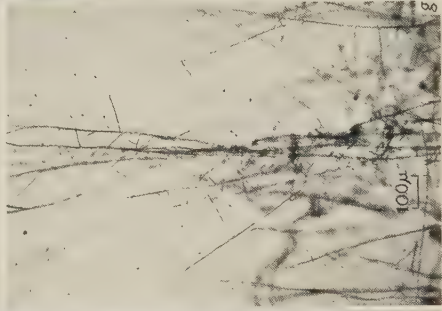
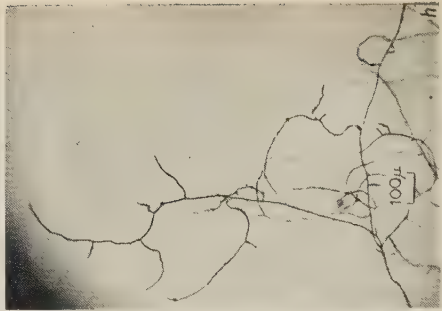
The analysis of the frequency distribution of different morphotypes (Text-fig. 2) is interesting, as it reflects the type of frequency distribution found by Fisher, Corbett and Williams (1943) and which is shown to have wide application in the analysis of natural populations (Williams, 1950). In the collection of samples bias is present. In proportion to the number of pear plantations, relatively more samples have been received from Wales and the west of England. Intensity of sampling is therefore related to those areas where, by their higher rainfall, scab outbreaks are most frequent.

The reason for the random distribution of morphotypes becomes clear when the problem of variation is examined on a more limited scale and the characteristics of particular isolates studied in detail. It is found (Text-fig. 3) that a series of isolates, which vary greatly in morphology and nutritional requirement, can parasitize a particular host successfully, and that they can spread from one host to another, where the two hosts are within the same biotype range.

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EXPLANATION OF PLATE 5

Venturia pirina

- a-d. Gross morphology of colonies.* *a, b, c* are replicate spores of three clones showing differences in growth rate and colony margins. *a*, regular margin; *b*, irregular margin; *c*, stunted growth; *d*, detail of a regular margined colony with a mutation in growth rate. *e-h. Details of colony form.* *e*, dense growth type, regular margin; *f*, sparse growth type bearing conidiospores; *g*, dense growth type, irregular margin; *h*, stunted growth type.

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THE EFFECT OF CARBON DIOXIDE ON THE GROWTH OF CERTAIN SOIL FUNGI

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(With 2 Text-figures)

Penicillium nigricans, *Gliomastix convoluta* and *Zygorrhynchus vuillemini* and several other soil fungi were grown in atmospheres containing various amounts of carbon dioxide. Growth was determined both by measuring the linear spread and the dry weight of the mycelium. Increase in the concentration of carbon dioxide beyond 5 % greatly inhibited *Penicillium nigricans*, a fungus restricted to the upper 5 cm. of the soil, but had much less effect on *Zygorrhynchus vuillemini*, abundant below 10 cm. *Gliomastix convoluta*, which occurred throughout the profile, was intermediate in its reaction.

The facultative anaerobic ability of fungi isolated from the lower layers of the soil has been stressed by previous writers. In view of the high concentration of CO₂ found in soil after rain (3.5-9.2 %), tolerance of CO₂, rather than of low O₂, may determine vertical distribution of soil fungi.

During an investigation of the fungi in some East Anglian soils it was shown that species differed greatly in their vertical distribution within a given soil type. Such differences in distribution are well known and have been recorded by many previous workers. The fungi isolated could be placed in one of three groups: (1) species which were abundant in the surface litter and uppermost layer of the soil, but were only occasionally isolated from a depth greater than 5 cm.; (2) species which were abundant in the lower layers of the soil but were absent or uncommon in the surface soil; and (3) a small group of species which seemed to be present throughout the soil profile.

Bisby, Timonin and James (1935), during their investigations into the fungi of Manitoba soils, showed that the samples taken from the deeper layers contained a higher proportion of fungi capable of behaving as facultative anaerobes than did the surface samples. In their work the tests for the ability to grow under anaerobic conditions were made by incubating the dilution plates in an atmosphere of carbon dioxide.

It was anticipated that in the fungi from the East Anglian soils a similar difference in anaerobic ability might be found. However, preliminary tests with the various fungi isolated, using gas mixtures containing amounts of oxygen varying from 1 to 20 %, failed to give results comparable with those of Bisby and his co-workers. Further experiments were then carried out using atmospheres containing different concentrations of carbon dioxide. Increasing the amount of carbon dioxide beyond about 3 % greatly affected the growth of some of the fungi, while others grew normally. Of the fungi tested *Penicillium nigricans* (Bain.) Thom, *P. restrictum* Gilman & Abbott, *P. janthinellum* Biourge, *P. spinulosum* Thom, and *Spicaria violacea* Gilman, were strongly inhibited by increasing the

amount of carbon dioxide. On the other hand, *Penicillium rugulosum* Thom, *Gliomastix convoluta* (Harz) Mason var. *felina* (Marchal) Mason, *Trichoderma viride* Pers. ex Fr., *Zygorrhynchus vuillemini* Namysl. and *Mucor rammannianus* A. Moeller showed little decrease in growth even in 10 % carbon dioxide.

The three fungi chosen for more detailed study were *Penicillium nigricans*, a fungus almost completely restricted to the upper 5 cm. of the soil examined, *Gliomastix convoluta* var. *felina* which occurred throughout the profile and *Zygorrhynchus vuillemini* which was abundant below 10 cm. but only occasionally isolated from the surface.

In the initial experiments the fungi were grown on agar in Petri dishes, and an estimate of growth was made by measuring linear spread. The *Zygorrhynchus* and *Gliomastix* were grown on malt-extract agar, the *Penicillium* on Czapek agar. After inoculation the Petri dishes were placed on a glass plate and covered with a large bell-jar fitted with glass tubes to allow the gas mixture to be passed through the jar. Cylinders of gas with the desired proportions of nitrogen, carbon dioxide and oxygen were connected to the bell-jars and the gas allowed to pass freely through the jar to sweep out the air present. All the mixtures contained approximately 20 % of oxygen and the increase in carbon dioxide was at the expense of the nitrogen. The gas mixture in the bell-jars was renewed three times a day. The jars were maintained at ordinary laboratory temperatures. There were two plates for each treatment and the colonies were measured along two diameters at right angles to each other. The measurements from each set were averaged. *Zygorrhynchus* was measured after 4 days, and *Gliomastix* and *Penicillium* after 27 days (Table 1). In Fig. 1 the results are expressed graphically, but the vertical scale differs for the different fungi so that the comparison of the different degree of inhibition is more readily seen.

It will be seen that the growth of *Zygorrhynchus* in 1.3 % carbon dioxide was much less than would be expected from the rest of the curve. Both cultures in that gas concentration showed an unexplained abnormal type of growth. Subsequent cultures in the same carbon dioxide concentration grew normally and at about the same rate as the cultures in air.

Further experiments were made in which the growth of the fungus was estimated by determining the dry weight of mycelium produced in liquid medium in the presence of various concentrations of carbon dioxide. Tests made with the various gas mixtures showed that the carbon dioxide dissolved readily in the medium. The pH of media such as Czapek fell rapidly to about pH 4.6 during the first 20 min. After this time there was little further change. In the latter experiments a malt-‘Marmite’ medium with an initial pH of 4.6 was used.

After several trials the most satisfactory method for maintaining the desired gas conditions was as follows. Conical flasks (250 ml.) were fitted with rubber stoppers through which passed a long and a short glass tube. Small plugs of cotton-wool were placed in the tubes about 1 cm. from their outer ends. Short lengths of rubber tubing were fitted to the tubes and screw clips added. 100 ml. of the culture solution was added

to each of the flasks which were then sterilized in the usual way and inoculated with a disk of mycelium on agar approximately 2 mm. in diameter. The longer tube was adjusted so that the lower end was a few millimetres above the surface of the culture fluid. Gas cylinders containing the desired mixtures were connected to large glass tubes, about 1.5 cm. diameter and about 50 cm. long, each with sixteen side arms. The flasks

Table 1. *Relation between linear spread and carbon dioxide concentration*

% CO ₂	...	0.04 (air)	1.3	5.6	10.2	14.6	20.0
Mean radius (cm.)							
<i>Zygorrhynchus</i>		6.7	5.28	6.30	6.37	6.15	5.15
<i>Penicillium</i>		3.25	3.25	—	1.20	0.48	0.23
<i>Gliomastix</i>		3.48	3.48	—	2.85	2.15	1.35

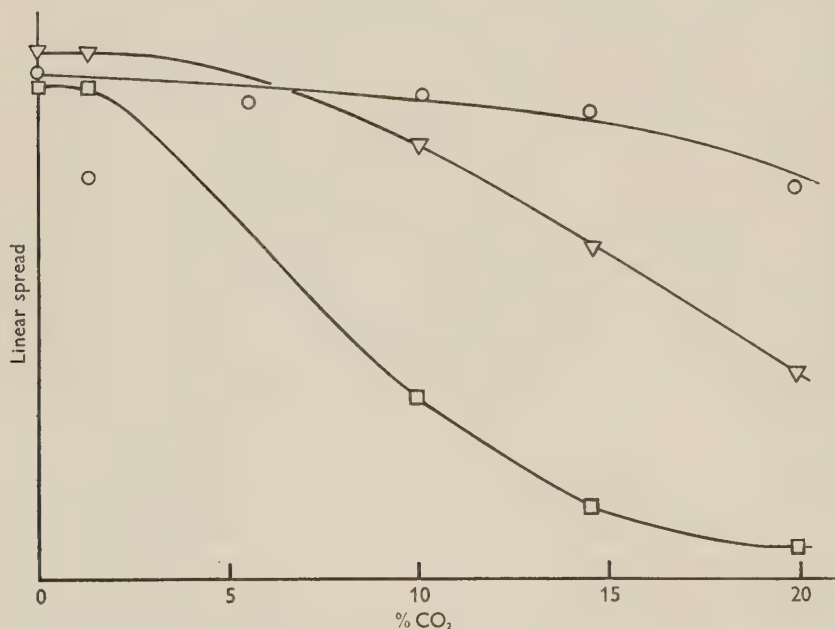


Fig. 1. Linear spread of *Zygorrhynchus* (O), *Gliomastix* (Δ), and *Penicillium* (□) on agar at different concentrations of carbon dioxide. Compare with Table 1.

were connected to the side arms by short lengths of rubber tubing. The gas was allowed to flow through the flasks fairly rapidly so as to sweep out the air. This was done about three times per day, and between these times the flasks were sealed by the screw clips. Samples of gas were withdrawn from the flasks from time to time and analysed by the usual Haldane apparatus. These analyses showed that the atmosphere above the cultures was being renewed sufficiently frequently. The *Zygorrhynchus* was allowed to grow for 6 days, the *Penicillium* for 9 days, and the *Gliomastix* for 11 days. At the end of the growth period the mycelium was removed from the flasks, washed and dried at 110° C.

In Fig. 2 the results obtained, which are based on five or six replicates, are summarized graphically as percentages of the maximum growths obtained.

Several series of experiments of the type described above have all given essentially the same results.

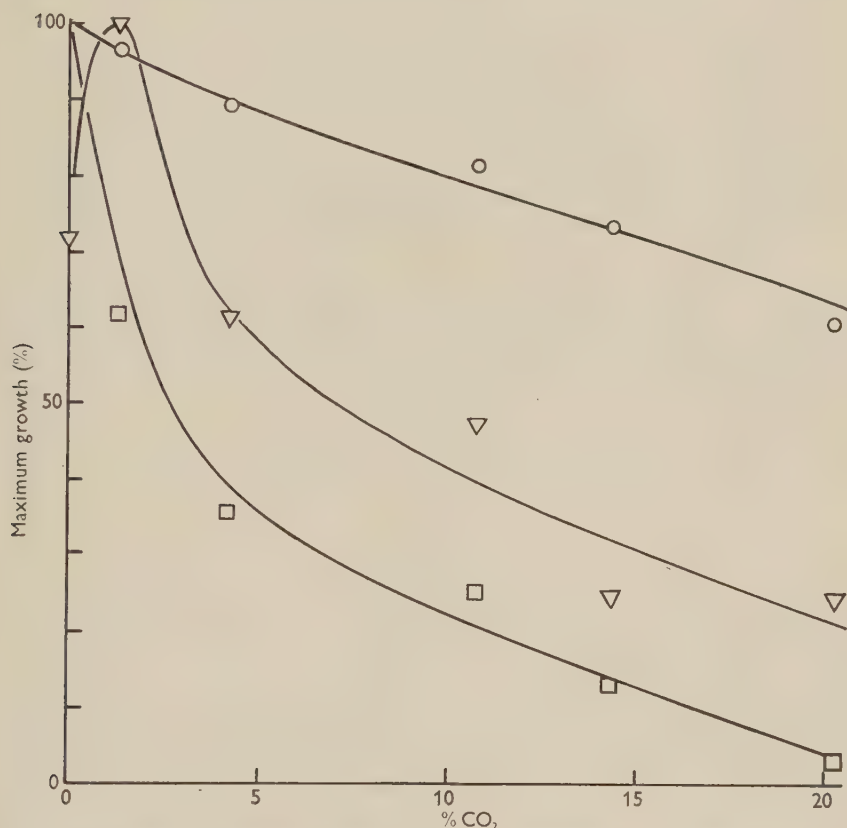


Fig. 2. Dry weight of mycelium produced by *Zygorrhynchus* (O), *Gliomastix* (▽) and *Penicillium* (□) grown in liquid media, expressed as a percentage of the maximum dry weight obtained.

DISCUSSION

The investigation forms part of a study of the factors determining the vertical distribution of soil fungi, and an account of the whole problem appears elsewhere (Burges, 1952). It has been shown (Burges, 1950) that the vertical distribution of fungi within a soil profile may be explained partly by determining the extent to which their spores will wash downward through the soil. *Zygorrhynchus* spores, for example, are easily washed downwards, *Penicillium* spores are not. The present work indicates that, even if spores of many different fungi are present in the lower layers of the soil, the amount of carbon dioxide present, by inhibiting the growth of

some species, will play a large part in determining the fungal flora which develops.

Analysis of gas samples from the Breckland soil, from which the fungi studied were isolated, showed that shortly after rain the percentage of carbon dioxide frequently was above 5 %. The amounts varied between 3.5 and 9.2 % for samples taken at 40 cm. a few days after rain. Such concentrations are well known to occur in heavy clay or peat soils, but may also be found in soils of fairly light texture. Conway (1936), during her investigations of the soil atmosphere of Wicken Fen, showed that the carbon dioxide may rise to 9.4 %. Romell (1922; see Conway, 1936, p. 377) records much higher values. During the investigation of the Breckland soil, which was a loose coarse-grained sand, it was somewhat surprising to find such high concentrations of carbon dioxide. Similar results in sandy soils have, however, been obtained by Vine, Thompson and Hardy (1942), working in Trinidad. It is interesting to note that they found appreciably more carbon dioxide following rain. Bisby *et al.* (1935) lay stress on the facultative anaerobic ability of fungi isolated from the lower layers of the soil. However, it would seem that their ability to grow in high carbon dioxide concentrations rather than in low oxygen must determine the fungal flora of the lower layers of the soil.

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THE ANTAGONISM OF *LAMBERTELLA CORNI-MARIS* TO FUNGI AND BACTERIA

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Lambertella corni-maris grown on a variety of agar media is strongly antagonistic to *Botrytis cinerea* and to many other fungi and bacteria. The effect is not attributed to pH change in the medium. The supernatant fluid from liquid cultures is also active, except against *B. cinerea*, where it has unexpectedly little effect on spore germination.

The fungus *Lambertella corni-maris* Höhnelt was first found by von Höhnelt (1918) on mummified fruits of the cornelian cherry (*Cornus mas* L.) in Austria. Further specimens were found in 1931 on mummified apples in Switzerland and on mummified pears at two places in south Germany (Harrison & el-Helaly, 1935). An isolate from Harrison's material was maintained for many years in the Imperial College Stock Culture Collection. During 1946 it was included among a wide range of fungi and other micro-organisms which was tested for antagonism to *Botrytis cinerea* on agar media. The general results of these investigations has already been reported (Wood, 1951). In one series of tests, colonies of various organisms 20–25 mm. in diameter were established on plates of nutrient agar which were then sprayed with a suspension of spores of *B. cinerea*. The width of the zone about the colony in which spore germination was inhibited gave a rough measure of the antagonistic properties of the organisms. Rather surprisingly, *Lambertella corni-maris* was placed in the group showing greatest antagonism, zones of inhibition 20–25 mm. wide being obtained on glucose/peptone agar. Similar results were obtained on a variety of natural and synthetic media. The growth rate on all media tested was relatively low with an optimum about 20° C. and decreasing rapidly above 25° C. The pH of the agar below or immediately beyond actively growing hyphae was normally in the range 4.0–5.0. On certain media, particularly potato-glucose agar, clusters of orange-yellow crystals appeared in relatively large quantities in a zone 10–15 mm. wide about the colonies. Occasionally, clusters of reddish coloured crystals also appeared. No attempt was made to isolate or identify these substances, preliminary experiments indicating that they were not very active antibiotics.

In further tests colonies 20–25 mm. in diameter were established on potato-glucose agar. Suspensions of spores or mycelial fragments of a variety of organisms were streaked from the periphery of the plate to the edge of the colony. The following were tested in this way: 3 bacteria, 1 Actinomycete, 1 Zygomycete, 1 Oomycete, 11 Ascomycetes and 10 Fungi Imperfecti. The Zygomycete (*Mucor hiemalis*) grew to within 4 mm. of the edge of the colony. Growth of all others was inhibited in zones 10–30 mm. wide.

The effect on bacteria was further investigated. The fungus was grown on a variety of agar and liquid media. Disks 11.0 mm. in diameter were cut from the agar immediately beyond colonies 20–25 mm. in diameter and placed in agar seeded with *Staphylococcus aureus*, *Bacterium coli* or *Mycobacterium phlei*. Similarly, 0.05 ml. of the various liquid media were placed in holes 11.0 mm. in diameter in seeded agar. After incubation for 48 hr. at 30° C. the zones of inhibition were observed.

The general results were that natural media gave better growth and production of antibiotics than synthetic media, and that *Bacterium coli* was less affected than *Staphylococcus aureus* and *Mycobacterium phlei* which behaved similarly in these tests. Striking results were obtained in some cases, particularly with disks taken from potato-glucose or glucose-peptone cultures, zones 30–35 mm. in diameter being obtained with *Staphylococcus aureus* and *Mycobacterium phlei* and 18–20 mm. with *Bacterium coli*. These zones were streaked with bromthymol blue indicator after they had formed, and were always found to have a pH value in the range 7.0–7.5. It is unlikely therefore that they were a result of the low pH of the agar disks or the liquid media.

Finally, it may be noted that while striking antagonism to *Botrytis cinerea* could always be demonstrated on agar cultures of the fungus, the supernatant fluid from liquid cultures had little or no effect on spore germination.

The above summarizes observations made intermittently over a period of a few months, and are reported because records of antibiotic production by members of the Discomycetes are few and the results obtained were striking and somewhat unexpected.

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HELICOSPOROUS HYPHOMYCETES. I

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(With Plates 6 and 7, and 9 Text-figures)

Seven helicosporous Fungi Imperfecti, found on decaying leaves in water, were isolated and grown in pure culture, viz. *Helicoon fuscoporum*, *Helicodendron paradoxum*, *H. triglitzensis*, *H. giganteum*, *H. multicatenuatum* n.sp., *H. westerdijkiae* n.sp. and *Spirosphaera floriforme* n.g., n.sp. Their cultural characters, spore development and germination are described and figured. Specific differences within the genus *Helicodendron* are discussed.

Since Linder (1929, 1931) published his excellent monograph on helicosporous Fungi Imperfecti, comparatively few references have been made to this group. Occasional collections, from rotting canvas (Olive, 1946), in marshy places (Ellis, Ellis & Ellis, 1951), during forays, and other more or less accidental findings, have been recorded. In recent years the interest in helicosporous fungi seems to be reviving. Lately some new species have been described (Boedijn, 1942; Glen-Bott, 1951), but still only a small number of Helicosporae have been grown and studied in pure culture (Rand, 1917; Linder, 1925, 1929; Glen-Bott, 1951; Webster, 1951).

This paper deals with some Helicosporae collected from decaying plant material in water. Linder collected his material chiefly from weathered bark and decaying wood fallen to the ground at the borders of brooks and in moist places. In the present investigation the fungi were collected from leaves and twigs taken from directly under the water surface of ponds, brooks and swamps, isolated, and grown in pure culture. The technique for collection and isolation was the same as that described by van Beverwijk (1951). The mounts used for the photographs and drawings were, unless otherwise indicated, made by letting a drop of cellulose acetate, dissolved in acetone, dry on the culture surface, the culture medium being either lupin stem or some agar medium. The thin film in which the fungus is embedded is then eased off and placed in a drop of lactic acid (with or without cotton-blue) on a slide and left for several hours in a warm place, until the cellulose acetate is dissolved. A coverslip is then gently lowered on the mount and sealed with nail varnish (a slight variant of the 'Necol' method as described by Ellis, 1950).

Cultures of the fungi described are available at the Centraal Bureau voor Schimmelcultures, Baarn. Dried cultures of the new species have been deposited in the herbarium of the Royal Botanic Gardens, Kew, in the herbarium of the Commonwealth Mycological Institute, Kew, and in the Rijksherbarium, Leiden, Netherlands.

Helicoon MORGAN, *J. Cincinn. Soc. nat. Hist.* **15**, 50, 1892

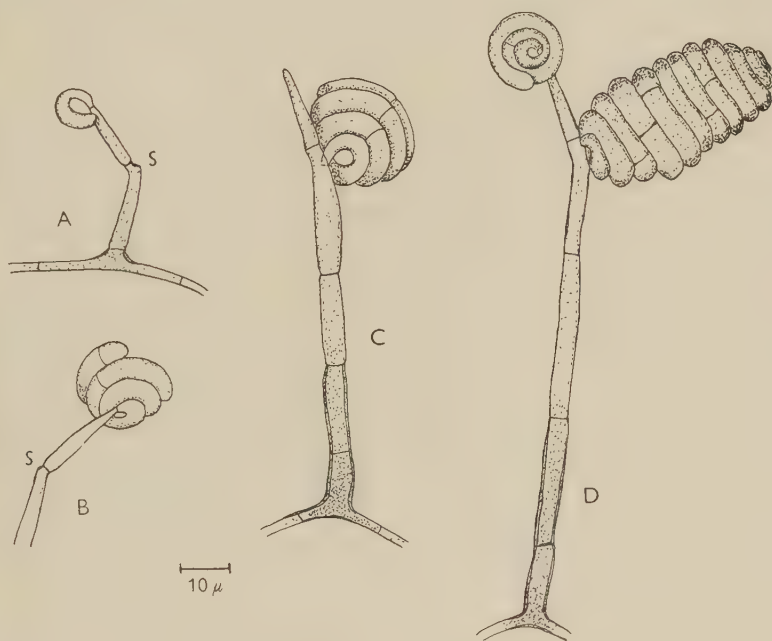
Helicoon fuscosporum Linder, *Ann. Mo. bot. Gdn*, **16**, 326, 1929

Three collections were made from birch leaves and fruit and from a willow leaf from a pond in a private garden near Ommen, Netherlands, in November 1947, and in March and October 1949. In October 1949 it was found on the buds of an oak twig collected from a pond in a wood near Baarn. During a visit to Sweden in July 1950, *H. fuscosporum* was found on birch leaves collected from a drainage furrow in a wood not far from Stockholm. Miss Glen-Bott sent to the C.B.S. a strain isolated from a beech leaf, collected at Waggoner's Wells, Surrey, November 1949.

The spores of my collections differed somewhat from those described by Linder in the size of the filament. According to Linder the filament in this species is $2.7-3\ \mu$ thick, whereas in my strains it measured $3.5-4.5\ \mu$. To ascertain whether my specimens were identical with Linder's species, I compared them with Linder's type material which was very kindly lent to me by the Farlow herbarium. The filament of Linder's strain was indeed somewhat narrower ($2.7-3.5\ \mu$), but in all other details of structure the fungi were in full agreement, so there seems no doubt that the isolates described in this paper are identical with *Helicoon fuscosporum*.

As Linder based his description on herbarium material of a single collection by Roland Thaxter, some observations made upon pure cultures may be of interest. Spores were picked off from the collected plant material with the aid of a glass needle and allowed to germinate in hanging drops of cherry decoction. The fungus grows well on cherry agar, 2 % malt agar and on lupin stem. Light favours spore development. On cherry agar the aerial mycelium is dark greyish green, the reverse is almost black as the substrate mycelium is deeply pigmented. On lupin stem the mycelial growth is not very dense and the conidiophores can be seen with a hand-lens. In liquid medium (cherry decoction) the mycelium develops in the medium, conidia, however, are only formed on the aerial mycelium. 'Necol' mounts of lupin stem cultures allow observations on the different stages of the development of the conidiophores (Text-fig. 1 A-D). These arise from the repent mycelium. At the foot of the conidiophore the hypha bearing it is slightly darker and the wall somewhat thickened. The conidiophore is thick-walled and dark at its base. Towards the apex the colour is more dilute brown to light fuscous. After one to four cross-walls have developed, a septum at the narrow tip of the conidiophore cuts off a small apical cell which begins bending to form the first coil of the conidium (Text-fig. 1 A). When the full-grown spore has fallen off, this septum is visible as a scar on the conidiophore. The first coils are rather narrow, forming the base of the spore, then they broaden, the top coils being somewhat narrower once more. Thus the mature spore has a blunt oval shape. The conidiophore continues growing, so that the originally terminal conidium becomes lateral. A septum is formed in this new segment of the conidiophore slightly above the developing conidium (Text-fig. 1 C, D). The direction of the spiral in all strains is counter-clockwise (definition according to Davidson & Gregory, 1938). Occasionally the

conidiophore is branched (Pl. 1, fig. 1). Chains of chlamydospores are observed in most strains. On lupin stem cultures each conidiophore generally develops three to eight conidia. The measurements are: conidiophore—bearing at least three conidia—100–160 μ high, 5 μ wide at the base, number of cross-walls between base and first conidium usually three (one to five). Conidia: 20–38 (50) μ long and 18–24 μ wide, filament 3.5–4.5 μ . Number of coils 8–12 (14), about three septa are formed in each coil.



Text-fig. 1 A–D. *Helicon fuscusporum* Linder. Young conidiophores. A, the conidium is coiling towards the observer; B and C, the developing conidia are coiling away from the observer; D, conidiophore bearing a mature conidium seen in its long axis. From the apex of the conidiophore a second conidium is developing, coiling towards the observer. The direction of coiling is counter clockwise. S, scar of a shed conidium. From lupin stem culture exposed to daylight.

Helicodendron PEYRONEL, *Nuovo G. bot. ital.*, N.S., 25, 460, 1918

Helicodendron paradoxum Peyronel, loc. cit. 25, 461–463, 1918

The type species of the genus *Helicodendron* was isolated from a grass leaf, from a pond in a wood near Baarn, October 1949. In fresh isolates this fungus shows the same colour characteristics as have been described from collected material, the spore tufts having at first a white, then an intense green, and finally a dull green to red-brown colour. The spore sizes, 15–20 μ in diameter, seemed to differ from those of Linder (1929, p. 330): 'the coiled conidia 35–40–60 μ in diameter'. Comparison with Peyronel's original description, however, showed that Linder misinterpreted Peyronel's measurements. Peyronel gave the length of the filament of the uncoiled spore, which Linder took for the diameter of the coiled

spore. A calculation from the enlargements of Peyronel's figures confirms that his coiled conidia had the same diameter as those of the above mentioned strain. The number of coils of the conidium in culture is somewhat greater, one to five (eight) coils, and the filament slightly narrower, $3.5-4.5\ \mu$, as compared with that of the conidia collected from plant material: $1-3\frac{1}{2}$ times coiled, filament $5.5-6.5\ \mu$. Conidia coil in either clockwise or counter-clockwise directions. Good growth and sporulation are obtained on lupin stem, *Acer* twig and 2 % malt agar. Spores are produced in abundance on a medium composed of cherry and oatmeal decoction with peptone, sucrose, dextrose and some nutritive salts. Day-light favours spore development.

Helicodendron triglitziensis (Jaap) Linder, *Ann. Mo. bot. Gdn*, **16**, 330, 1929

Helicomycetes triglitziensis Jaap, *Verh. bot. Ver. Brandenb.* **58**, 43, 1916

Helicodesmus albus Linder, *Amer. J. Bot.* **12**, 259-269, 1925

This fungus has been previously studied and cultured by Linder (1925, p. 268), who states that 'culture experiments indicate clearly that conidium production is dependent on exposure to sunlight'. In his monograph (Linder, 1929, p. 260) he corrects this observation saying that 'sunlight apparently had little effect on sporulation unless the material had been exposed to freezing conditions and then returned to the temperature of the laboratory'. In the present investigation this species is grown on lupin stem and cherry agar, the cultures, kept at room temperature before a window facing west, sporulate abundantly, conidia often covering the entire surface of the medium. This seems to be in favour of Linder's first conclusion.

Helicodendron giganteum Glen-Bott, *Trans. Brit. mycol. Soc.* **34**, 275-279, 1951

A strain of this species was isolated from a birch leaf collected from a drainage furrow in a wood at Hemfosa near Stockholm, Sweden, July 1950. It agreed in all respects with the strain described and cultured by Miss Glen-Bott. On lupin stem culture still another method of chain formation was observed. On this medium short chains develop in which each young spore is continuous with the top coil of the mother spore, and successive spores are marked only by a narrowing of the coils (Pl. 6, fig. 2).

Helicodendron tubulosum (Riess) Linder, *Ann. Mo. bot. Gdn*, **16**, 330-332, 1929

Helicomycetes tubulosus Riess, *Beitr. Pilzk.* **11**, 140, 1853

Helicoon tubulosum (Riess) Saccardo, *Syll. Fung.* **11**, 609, 1895

Some confusion exists in the literature concerning *Helicodendron tubulosum*. Several different species seem to have been described under this name. As Miss Glen-Bott is studying this problem, all strains allied to this species, collected during this investigation, were sent to her. Therefore this species will not be dealt with in this paper.

***Helicodendron multicatenulatum* sp. nov.**

Fungus aëro-aquaticus mycelio repente, ramoso, septato, fusco. Conidiophora non plane distincta a mycelio vegetante. Conidia formata in mycelio aërio, fusca, laxe convoluta vicibus $2\frac{1}{2}$ (1-7) in tribus planis, diametro $15-25\mu$, fila $4-4.5\mu$ lata, septis 1-9. Procreatione e compluribus conidii cellulis novorum conidiorum racemi inter se cohaerentes oriuntur.

Hab. In foliis sub aqua putrescentibus, Baarn, Hollandia.

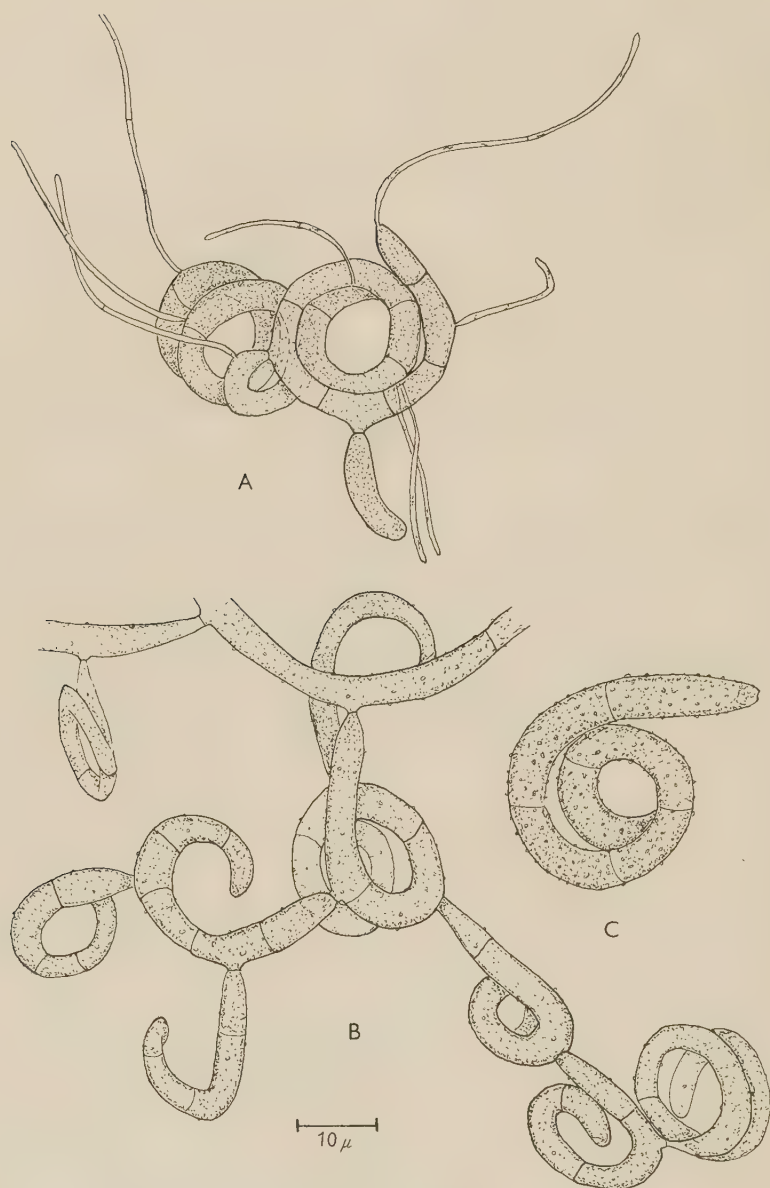
Aero-aquatic fungus with branched, septate, fuscous mycelium. Conidiophore not sharply differentiated from the vegetative mycelium. Conidia produced on the aerial mycelium, fuscous, loosely coiled in three planes, $15-25\mu$ in diameter, filament $4-4.5\mu$ broad, $2\frac{1}{2}$ (1-7) times coiled, with 1-9 septa. By proliferation from several cells of the conidium entangled spore clusters are formed.

On decaying leaves in water, Baarn, Netherlands.

Two strains of this fungus were isolated. One from a grass leaf collected from a marshy spot in an almost dry pool, July 1949 (typus). The other strain was found growing on a decaying oak leaf collected from another pond in the same wood near Baarn, 10 days after the frost broke, February 1950.

On the plant material the fungus developed groups of fuscous spirals, either directly on the leaf, or on ascending conidiophores about two or three times the length of the spore cluster they bore. Sometimes several clusters were seen in a row on the same conidiophore. These spore groups could easily be picked off with a glass needle and grown in pure culture. In a drop of cherry decoction the conidia germinate readily, narrow germ tubes developing from several cells (Text-fig. 2A). The fungus grows well on cherry agar, 2 % malt agar, potato-dextrose agar and in a liquid medium of cherry decoction and 2 % malt. On lupin stem the development is less abundant, and sporulation occurs only on the agar of the inoculum and in the mycelium tuft at the upper end of the stem. The best fructification is obtained in cultures on cherry agar and 2 % malt agar, exposed to the light. On cherry-agar plate culture the fungus reaches a diameter of 4 cm. in about 4 weeks. The texture of the aerial mycelium is woolly in the centre and felty towards the margin (terminology as suggested by Nobles, 1948, pp. 287-8). A young culture is bluish green, turning dark olive-green to brownish grey as the culture ages (4-5 weeks). The substrate mycelium is almost black. Conidia develop in the aerial mycelium, at first in the centre, then spreading all over the culture. The conidial clusters are bluish grey, somewhat lighter than the aerial mycelium. In test-tube slopes spore production is usually more abundant than in Petri dish cultures on the same medium. In young cultures in liquid medium (cherry decoction with 2 % malt) wavy and curved conidiophores may be seen in the liquid; when they pierce the surface film of the medium, coiled conidia are produced on the aerial growing part of the conidiophore.

The mycelium is fuscous, rather thick-walled, hyphae $2.5-4.5\mu$ broad. Anastomoses are frequent, especially in the substrate mycelium. The conidiophores are not sharply differentiated from the aerial mycelium; it is impossible to be certain where the mycelium ends and the conidiophore begins. In young, fast-growing cultures conidia appear to originate from



Text-fig. 2. A, *Helicodendron multicatenulatum* n.sp. Germinating conidia. After 24 hr. in cherry decoction, narrow germ tubes are produced from several cells of the spore. (Mounted in lactic acid.) B, *H. multicatenulatum*. Detail of a spore group, showing the tapering proximal cells of the conidia, and the direction of coiling, which is clockwise in the first conidium (middle), counter clockwise in the next to the right and clockwise again in the last conidia to the right and left. From a 16-day culture on lupin stem. The incrustation of the spore wall has been partly dissolved by the mounting fluid. C, *H. multicatenulatum*. Conidium, dry mount, showing the incrustated spore walls. From culture on cherry agar.

the hyphae directly. In older cultures long, wavy conidiophores (or conidiophore-like hyphae) lift the spore cluster just above the aerial mycelium. The free end of the conidiophore curves to form the first conidium (Pl. 6, fig. 3). Again, there is no marked difference between the end of the conidiophore and the first, often broadly curved conidium. Each conidium may proliferate from several cells; thus, a cluster of entangled chains of spiral spores is formed (Pl. 6, fig. 4). On cherry agar spore clusters of $160\text{--}270\mu$ are measured. Branches of the conidiophore may give rise to new conidial clusters. The conidia are loosely and sometimes irregularly coiled in three planes, $15\text{--}25\mu$ in diameter, or larger if very loosely coiled. The filament is $4\text{--}4.5\mu$ broad, 2μ at the tapering proximal end of the conidium, and is $2\frac{1}{2}$ (1-7) times coiled; according to the number of coils 3-9 septa are formed (Text-fig. 2B; Pl. 6, fig. 5). The spirals are mostly coiled clockwise, but the direction of coiling is not constant. The conidia are not readily detached. The spore cluster, however, easily breaks up into short chains or single conidia when teased out. The cell walls of the conidia, the conidiophores and also of the aerial mycelium are incrustated (Text-fig. 2C). This crystalline substance dissolves in water and in lactic acid. In mounts the cell walls appear smooth or nearly smooth; here and there some remains of granules or crystals are seen in the mounting fluid.

Because of the gradual development of the mycelium into the conidiophore and of the conidiophore into the conidium, the fungus under consideration was compared with descriptions and figures of fungi with circinate hyphae. The curved, rough hyphae of *Campotrichum podospermum* Corda (1839, Pl. 12) somewhat resemble the present species. Corda's fungus, however, has very marked black, erect conidiophores, and non-septate helicoid branches. In the genera *Sarcopodium* Ehrenberg and *Helicotrichum* Nees the curved hyphae are unbranched.

Although in *Helicodendron multicatenuatum* the conidia may in some respects resemble coiled branches of the mycelium, the conidial cluster as a whole is markedly different from the mycelium (Pl. 7, fig. 1). The manner of spore formation shows a close resemblance to that of *H. paradoxum* and *H. triglitzensis*. It is therefore proposed to include this fungus in the genus *Helicodendron*. The specific epithet, *multicatenuatum*, is suggested by the many spore chains originating from a single conidium.

***Helicodendron westerdijkiae* sp. nov.**

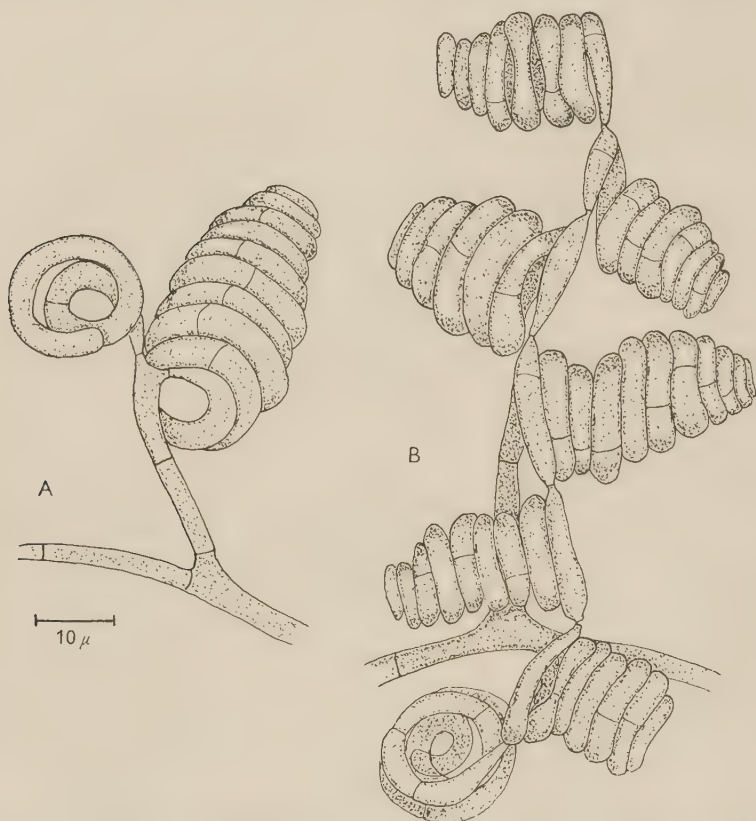
Fungus aëro-aquaticus mycelio repente, ramoso, septato, fusco. Conidiophora rami simplices mycelii $25\text{--}50\mu$ longi, prope basim $3\text{--}3.5\mu$ lati. Conidia apicalia, plerumque e volumine spirae proximo basi procreantia, catenas ramosas et racemos formantia. Conidia subfusca, fila $3\text{--}4\mu$ lata, in tribus planis convoluta 9-12 vicibus in corpus ovatum, $22\text{--}35$ (40) μ longum, $15\text{--}19\mu$ latum.

Hab. In folio Aceris sub aqua putrescente, Baarn, Hollandia.

Aero-aquatic fungus with branched, septate, fuscous mycelium. Conidiophores simple branches of the mycelium $25\text{--}50\mu$ long, $3\text{--}3.5\mu$ in diameter at the base. Conidia terminal, proliferating mostly from the basal coil, forming branched chains and clusters. Conidia light fuscous, the filament, $3\text{--}4\mu$ thick, is coiled in three planes to form a 9-12 seriate blunt oval body, $22\text{--}35$ (40) $\times$ $15\text{--}19\mu$.

On a decaying sycamore leaf in water of pond in a wood, Baarn, Netherlands, October 1949.

On the leaf little of the structure of the fungus is seen, only a few groups of spores being just visible. These spores, when transferred to a suitable medium, cherry decoction or cherry agar, germinate readily, sending



Text-fig. 3. A, *Helicodendron westerdijkiae* n.sp. Young conidiophore. The first conidium on the right-hand is mature, it has coiled away from the observer. The conidium on the left-hand has just finished its second coil, and is coiling towards the observer. The direction of coiling of both spores is counter-clockwise. (From lupin stem culture.) B, *H. westerdijkiae*. Conidiophore with two developing spore chains, one points upwards, the other is bent downwards, probably in consequence of the mounting. From a 6-week culture on lupin stem.

out germ tubes from several cells of the conidium. The colony on cherry agar or lupin stem is greenish grey and has a woolly texture. Conidia generally develop close to the medium and are often covered by the aerial mycelium. Good sporulation is obtained on lupin stem, 2 % malt agar and cherry agar; on Lutz agar little or no sporulation occurs. Light favours spore development. A culture in cherry decoction exposed to daylight developed conidia close to the surface of the liquid, some submerged spores were also observed. On most media sclerotia develop. When two to three septa have been formed the apex of the conidiophore

bends to produce the first conidium, often a second conidium is formed close to the first (Text-fig. 3A). By proliferation from the basal coils, chains of spores are formed (Text-fig. 3B). The conidia point in all directions round their common axis (Pl. 7, fig. 2). Other coils than the basal coil may also take part in chain formation, thus branched chains and clusters of spores develop. The direction of coiling is counter-clockwise.

H. westerdijkiae differs from *H. fuscum* (Berk. & Curt.) Linder in the larger size of filament and conidia.

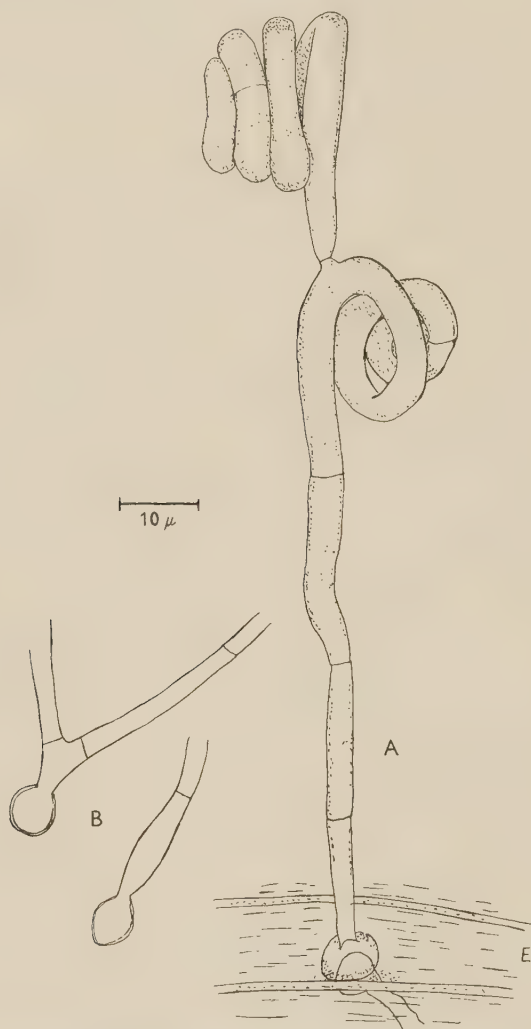
As may be gathered from the foregoing descriptions, the genus *Helicodendron* contains a number of species which vary considerably in some of their morphological characteristics. The most important common character of these species is their method of producing spores in chains. Details of structure of these spore chains, however, vary greatly from one species to another.

In *H. westerdijkiae*, as in *H. tubulosum*, the daughter spores usually grow out from the basal coils of the mother spore, the long axes of the spores being perpendicular to the common chain formed by their basal coils. In *H. giganteum* the proliferation generally occurs from about the middle of the mother spore (Glen-Bott, 1951, Text-fig. 3). In lupin-stem cultures of this species short chains of conidia are also formed by proliferation of the apical coil (Pl. 6, fig. 2). In *H. triglitzensis* (Linder, 1929, Pl. 27, fig. 1), *H. paradoxum* and *H. multicatenuatum* the young conidia may grow from practically any cell of the mother-coil, thus producing tangled chains (Text-fig. 2B; Pl. 7, fig. 1). The connexion between mother coil and daughter spore is characteristic in this genus. At the point where the young spore is attached to the mother coil a small projection is present, a septum which is about half the normal diameter of the filament separates the two spores. Thus the basal cell of each conidium tapers to its proximal end (Text-figs. 2B, 3B).

The conidia in this genus show considerable differences in shape and colour. An ovoid coiled spore (more than 4-seriate) occurs in *H. tubulosum* and allied species, *H. giganteum*, *H. hyalinum* and *H. westerdijkiae*. Whereas *H. triglitzensis*, *H. paradoxum* and *H. multicatenuatum* form conidia with a rather flat top and bottom, developing generally less than four coils. The shape of these conidia might best be compared to that of a tangerine (Text-fig. 4A). Most of the species placed in this genus have hyaline to yellowish spores: *H. tubulosum*, *H. triglitzensis*, *H. giganteum* and *H. hyalinum*. One species, *H. paradoxum*, has hyaline spores which become sub-fuscos with age. Three species have fuscous spores: *H. fuscum*, *H. westerdijkiae* and *H. multicatenuatum*.

Several *Helicodendron* species (*H. triglitzensis*, *H. paradoxum*), when grown on a solid medium such as lupin stem, develop a swollen basal cell where the conidiophore pierces the epidermis of the stem (Text-fig. 4A, B). Conidiophores arising from the aerial mycelium in the same culture do not develop a basal cell. This characteristic was also observed, although less frequently, on conidiophores of *Spirosphaera floriforme* (see below) when grown on lupin stem (Text-fig. 5). Recently, a similar structure was figured by Ellis *et al.* (1951, fig. 5) for *Napicladium arundinaceum* (Corda) Sacc.

Notwithstanding the specific differences in the formation of chains and in the shape and colour of the conidia, there does not seem as yet enough ground to split *Helicodendron* into different genera.



Text-fig. 4 A, B. *Helicodendron* species, showing swollen basal cells of conidiophores. A, *H. tri-glitzensis*. B, basal parts of conidiophores of *H. paradoxum*. Both from lupin stem culture. E, epidermis of the lupin stem on which the fungus was cultured.

Spirosphaera gen.nov.

Fungus aëro-aquaticus mycelio repente, ramoso, septato, hyalino vel fusco. Conidiophora non multum distincta. Conidium constat e spiris ramosis, septatis.

Aero-aquatic fungus with branched, septate, hyaline to fuscous mycelium. Conidiophore little differentiated. Conidium consisting of branched, septate coils.

***Spirosphaera floriforme* sp. nov.**

Fungus aëro-aquaticus mycelio repente, ramoso, septato, hyalino vel fusco. Conidiophora rami non multum distincti in mycelio aërio formati. Conidia globosa vel subglobosa, quae constant e spiris laxè perplexis, ramosis, septatis, hyalinis vel subfuscis, diametro 50–120 μ ; fila spirarum 3.5–5.5 μ lata.

Hab. In foliis sub aqua putrescentibus. Ommen et Baarn (Hollandia), Haslemere (Anglia).

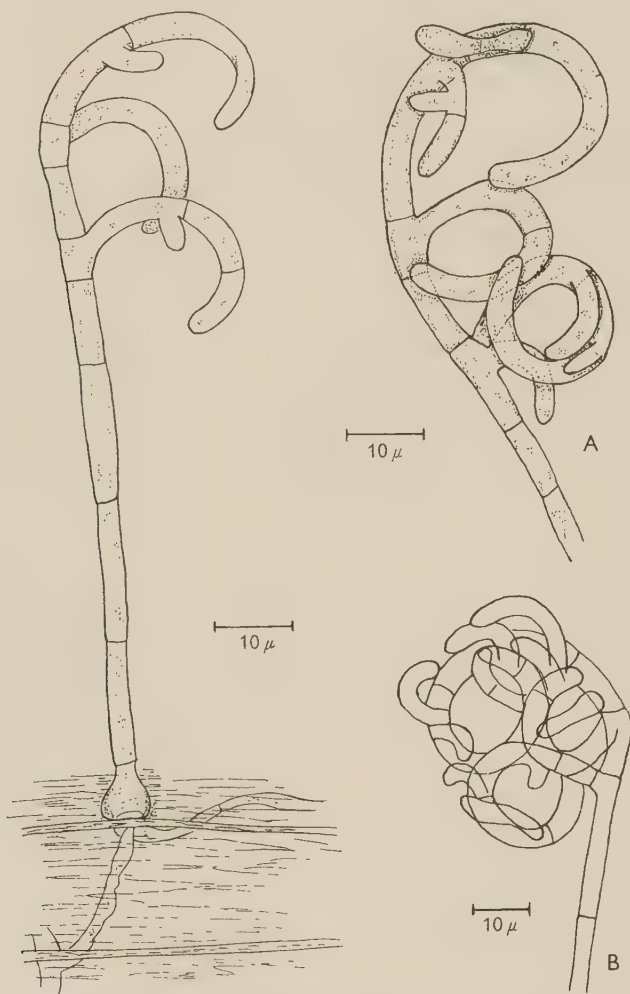
Aero-aquatic fungus with branched, septate, hyaline to fuscous mycelium. Conidiophores little differentiated branches on the aerial mycelium. Conidia spherical to subspherical bodies, consisting of loosely interwoven branched, septate coils, hyaline to light fuscous, 50–120 μ in diameter, the filament of the coils 3.5–5.5 μ thick.

On decaying leaves in water. Ommen and Baarn, Netherlands; Haslemere, England.

This fungus has been collected on three occasions from a pond in a private garden near Ommen. It was found growing on decaying birch leaves, November 1947 (typus), March 1949, on a rhododendron leaf, July 1949, and on a birch leaf from a pond in the wood near Baarn, November 1951. A strain of the same fungus was sent to the C.B.S. by Miss Glen-Bott who isolated it from a decaying oak leaf, collected from a pond near Haslemere, Surrey.

When the leaves are taken out of the water most of the spores have fallen off, but when they are kept under moist conditions in a Petri dish for some days, new conidia develop just above the water film on the leaf, forming a white powdery layer which can be seen by the naked eye. Spores, and also fragments of spores, germinate readily, one strain being cultured from a four-celled spore segment. The fungus grows on most of the ordinary culture media, the best development being obtained on cherry agar; light favours sporulation. On cherry-agar plate the fungus attains a diameter of about 7 cm. in 4 weeks. The growth is felty to subfelty with intertwined hairs on the inoculum. The colour is dark grey, somewhat lighter towards the edge. The marginal 1 mm. is colourless, it consists mainly of substrate mycelium with a sparse growth of aerial hyphae. Some faint radial furrows may develop. Spores are produced at first on and near the inoculum, later extending towards the edge of the culture, forming a white powdery layer on the grey mycelium. On malt agar growth is good, but spore production less abundant. In cherry decoction development is good and spores are produced just above the liquid. On lupin stem the aerial mycelium is white to greyish, sporulation good. In this species the conidiophores are not sharply differentiated from the rest of the aerial mycelium. The free end of the conidiophore broadens slightly, then bends to form about one coil of a spiral. One to several side branches of the conidiophore, slightly below the first coil, may develop in the same way (Text-fig. 3). In the meantime branches of these coils develop in all directions, coiling and sending off coiling branches likewise. Several septa are formed in each coil (Text-fig. 6A, B). The branches are not constricted at their points of origin. Thus an almost spherical conidium is produced, consisting of intricately coiled branches (Pl. 6, fig. 7). The conidium is at first hyaline, turning dull white in

cultures at least 2 months old. Older spores easily break up into fragments under the slight pressure of a coverglass.



Text-fig. 5.

Text-fig. 6.

Text-fig. 5. *Spirosphaera floriforme* n.sp. Hyphae growing through the epidermal cells of a sterilized lupin stem, and a young conidiophore with swollen basal cell growing on the surface of the stem.

Text-fig. 6A, B. *Spirosphaera floriforme*. A and B, developing conidia. The pattern of the branching coils is getting more and more complicated. From culture.

Similar structures as seen in the developing conidium of *Spirosphaera floriforme* were figured by Hotson (1912, pl. 9, figs. 1-6) showing early stages in the development of the bulbils of *Papulaspora spinulosa*. Soon, however (Hotson, p. 9, fig. 7), these coils develop into the body of the bulbil, whereas the conidium of *Spirosphaera floriforme* consists of loosely intertwined spiral segments which easily break apart when the spore is crushed.

No description of this fungus could be found, nor a genus in which it could be placed. It is therefore decided to make the present species the type of a new genus. The generic name, *Spirosphaera* is suggested by the approximately spherical shape of the conidium which is built up out of spiral segments. The specific epithet of the fungus is chosen because the full-grown spore reminds one of the flower of *Chrysanthemum coronarium*.

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EXPLANATION OF PLATES 6 AND 7

PLATE 6

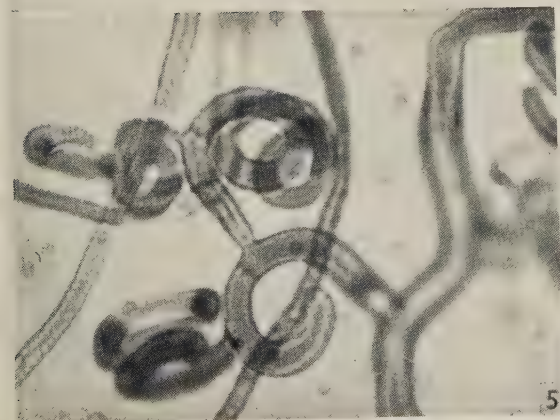
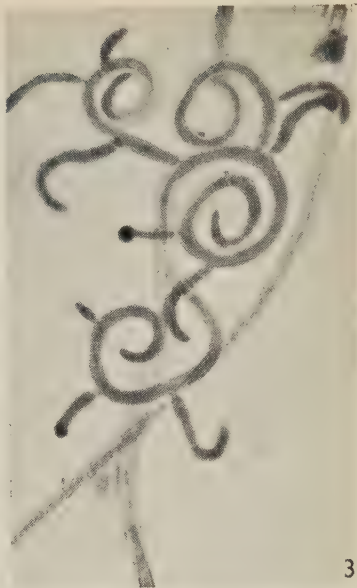
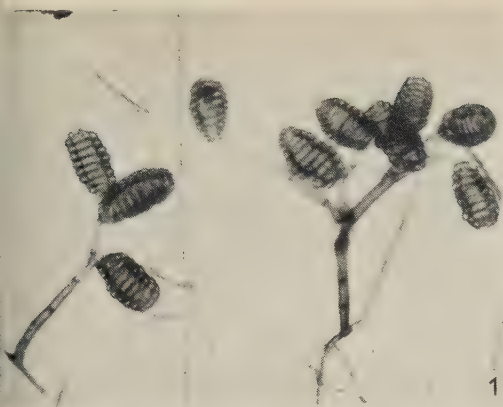
- Fig. 1. *Helicoon fuscosporum* Linder. Conidiophores with mature conidia. To the right a branched conidiophore, to the left a simple conidiophore with three septa proximal to the first conidium and one septum just above this conidium. The basal part of the conidiophore is darker because of its thickened walls. From a 2-month culture on lupin stem. $\times 260$.
- Fig. 2. *Helicodendron giganteum* Glen-Bott. Chain-formation by proliferation of the top coil of the spore. From a 5-week culture on lupin stem. $\times 235$.
- Fig. 3. *H. multcatenulatum* n.sp. Young conidiophore, the second and third set of conidia are just beginning to coil. Where the filament is exactly in focus, the wall still shows a slight roughness. From a 2-week culture on cherry agar, grown in daylight. $\times 600$.

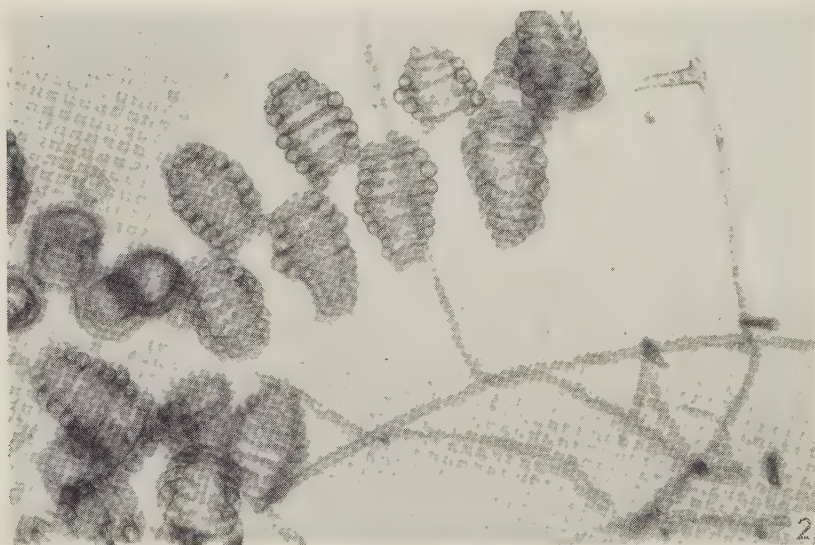
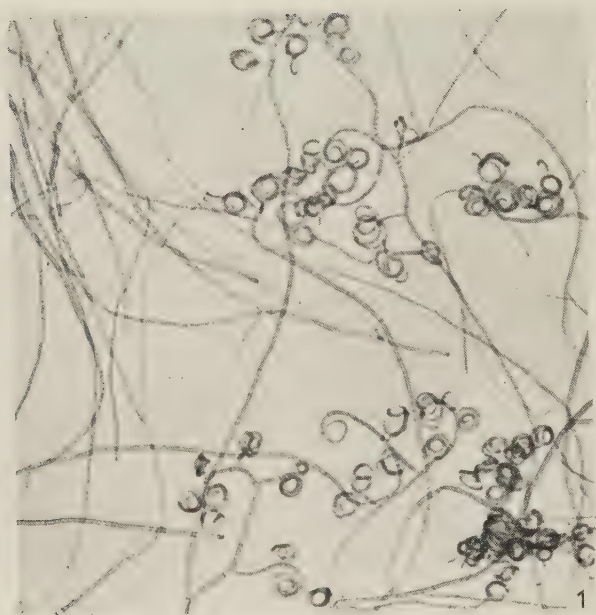
- Fig. 4. *H. multicatenuatum*. Three developing spore clusters. In the spore group to the right at least five spore chains are growing out from one conidium. From the same culture as in previous figure. $\times 235$.
- Fig. 5. *H. multicatenuatum*. Detail of spore group, showing daughter conidia growing out, generally just before a cross-wall. The proximal cell of each conidium tapers towards its point of origin. From a 7-week culture on lupin stem. $\times 950$.
- Fig. 6. *Spirosphaera floriforme* n.sp. Developing conidium, in about the same stage of development as that in Text-fig. 6B. From the edge of an 8-day slide-culture, mounted in lactic acid with cotton blue. $\times 660$.
- Fig. 7. *S. floriforme*. Nearly mature conidia, showing the entangled structure of branched coils. From culture. $\times 400$.

PLATE 7

- Fig. 1. *Helicodendron multicatenuatum*. Young clusters of conidia against background of mycelium. Although the aerial mycelium gradually passes into a conidiophore and this into the conidium, there is yet a marked difference between conidia (right) and mycelium (left). From the same culture as in Pl. 6, fig. 3. $\times 190$.
- Fig. 2. *H. westerdijkiae* n.sp. Conidiophore with spore chain. The long axes of the lower conidia are more or less parallel to the plane of observation, those at the upper end of the conidiophore are perpendicular to it, and therefore are not quite in focus. From a 6-week culture on lupin stem. $\times 460$.

(Accepted for publication 10 April 1952)





HYPOGEOUS FUNGI FROM MALAYA

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(With 2 Text-figures)

The following species are described: *Hydnangium virescens* n.sp., *H. echinulatum* n.sp., *Arcangeliiella beccarii* (Petri) Dodge & Zeller, *A. malaiensis* n.sp., *Elasmomyces borneensis* (Petri) Dodge & Zeller, *E. malaiensis* n.sp., *Stephanospora penangensis* n.sp., *Wakefieldia striaespora* n.gen., n.sp., *Chamonixia mucosa* (Petri) Corner & Hawker n.comb., *C. octorugosa* n.sp., *Dendrogaster cambodgensis* Patouillard, *D. aurantius* n.sp., *Hymenogaster viscidus* Massee & Rodway, *Hysterangium purpureum* Zeller & Dodge var. *malaiense* n.var., *Elaphomyces singaporensis* n.sp., *E. carbonaceus* n.sp.

Specimens of hypogeous fungi were collected by one of us (E.J.H.C.) in Malaya, and the following descriptions have been compiled from original field notes and from an examination of material dried or preserved in formalin alcohol. The colours mentioned refer to living specimens unless otherwise stated. Type material has been deposited at Cambridge (Corner Collection, Botany School), and at the Herbarium, Royal Botanic Gardens, Kew; duplicates of most collections have also been sent to: British Museum (Natural History); Museum National d'Histoire Naturelle, Paris; Rijksherbarium, Leiden; United States Department of Agriculture, Mycological Collections, Beltsville; Botanic Gardens, Singapore.

I. BASIDIOMYCETES

A. Spores spherical or nearly so, epispore spiny or ridged

***Hydnangium virescens* Corner et Hawker sp.nov.**

Receptacula depresso-globosa sessilia furfuracea, albida vel pallide ochracea, tactu sordide virescentia, peridio tenui, gleba pallida dein purpureo-brunnea, locellis labyrinthiformibus angustis occlusis: basidia $18-23 \times 8-9.5 \mu$ tri- vel quadrispora, sterigmatibus brevibus: sporae $8.5-10 \times 7-8.5 \mu$, fusco-cinnamomeae, quasi globosae, echinulatae.

Collected: Reservoir Jungle, Singapore, 11 December 1930 (type), 17 January 1931, 20 April 1931; Bukit Timah, Singapore, 24 March 1940, 10 December 1940; Sungei Pelepah, Kota Tinggi, Johore, 26 July 1931; Ulu Tiram, Johore, 4 November 1934. (Corner, Nos. 728-733.)

Fruit-bodies: 2.2-3.5 cm. wide, subglobose or somewhat depressed and flattened, sessile, arising from narrow mycelial strands; scurfy to sub-tomentose $\pm$ villous; white becoming pallid ochraceous above, sometimes rather deep coloured in places, pallid white below, turning dull greenish on bruising (water colour in Corner's collection, Botany School, Cambridge). Scurfiness of peridium obvious in dried material particularly at base, fruit-bodies drying with indentation at apex and with considerable

wrinkling and tendency for peridium to split, peridium drying ochraceous buff, gleba cocoa coloured. *Peridium*: thin (about 0.3 mm.), firm, white, cut surfaces *not* turning green, extreme outer layer loose and cottony, hyphae projecting up to 10 μ from surface, bulk of peridium of closely packed hyphae (6–12 μ occasionally up to 15 μ wide) arranged parallel to surface of fruit-body, with scarcely thickened walls, pale yellow at surface; narrow inner layer of firm, thick-walled hyphae (4–7 μ wide), distinct from gleba, forming slight cushion at base. *Gleba*: pale fuscous-purplish-drab, becoming chocolate-coloured when mature, rubbery gelatinous, tough and elastic, wholly pervaded by gyrose, labyrinthine tramal plates enclosing very narrow and occluded cavities. Sterile base absent, plates not obviously radiating from centre. Tramal plates consisting of loosely interwoven mucilaginous hyphae (3–5.5 μ wide), resembling those of inner peridium. Latex vessels absent. *Basidia*: mostly collapsed, about 18–23 $\times$ 8–9.5 μ , 3–4-spored. Sterigmata not more than 1 μ long. *Spores*: fuscous cinnamon (fuscous ochraceous under microscope), ellipsoid to nearly spherical, 8.5–10 $\times$ 7–8.5 μ , echinulate, colourless spines about 1 μ long, not amyloid, 1 gutta (0.5 μ wide) or none (Fig. 1a). *Odour*: strong, nauseating, suggestion of pea soup or chicken broth.

Gregarious, half buried in soil by dead stumps.

The spore characters are unlike those of any previously described species of *Hydnangium* or *Arcangeliella* which show greening on bruising.

***Hydnangium echinulatum* Corner et Hawker sp. nov.**

Receptacula depresso-globosa sessilia, verrucis conicis instructa, cervino-brunnea, gleba disco basali sterili parvo praedita, locellis parvis, dissepimentis albidis, fractu cyano-nigrescentibus: sporae 8–9 μ , obscure aureo-brunneae, globosae, echinulae.

Collected: Sungei Nipah, Kemaman, Trengganu, 24 June 1932. (Corner No. 746 type.)

Fruit-bodies: sessile, attached to slender fawn mycelial strand, globose-depressed, flattened, often angular from mutual pressure, 1.8–3.0 cm. wide $\times$ 1.5–2.4 cm. high, closely covered with firm hard-pointed conical fawn-brown warts which are often faintly grooved longitudinally (splitting in dry material) and bent or curved at apex, rather like those of *Lycoperdon echinulatum*. *Peridium*: outer layer of warts, inner layer thin (about 0.5 mm. thick), white, quickly discolouring to deep indigo and finally black on cutting, drying dingy yellow. *Gleba*: basal disk slightly developed, cavities numerous, small, simple, not compressed, filled with dark spores, tramal plates white, becoming indigo-black on cutting, central strand 150 μ wide of closely interwoven hyphae, outer looser zones, total width of tramal partition 400–500 μ . Drying cinnamon to dingy red brown. *Basidia*: not seen, cavities filled with spores and apparently crossed by loose hyphae. *Spores*: spherical, 8–9 μ diameter, dark in mass, dark golden brown under microscope, irregularly spiny, spines 2–3 μ long, rather blunt, about 1 μ broad at base (Fig. 1b).

On soil, more or less buried in leaves in jungle at edge of river.

No previously described species of *Hydnangium* or of any related genera has an echinulate peridium.

Archangeliella beccarii (Petri) Dodge & Zeller

Single specimen from Gunong Baling, Kedah, 25 November 1941.

Fruit-body: 1.5 cm. subglobose, sessile, giving out white milk which quickly turns yellow on exposure to air. (Water colour in Corner's

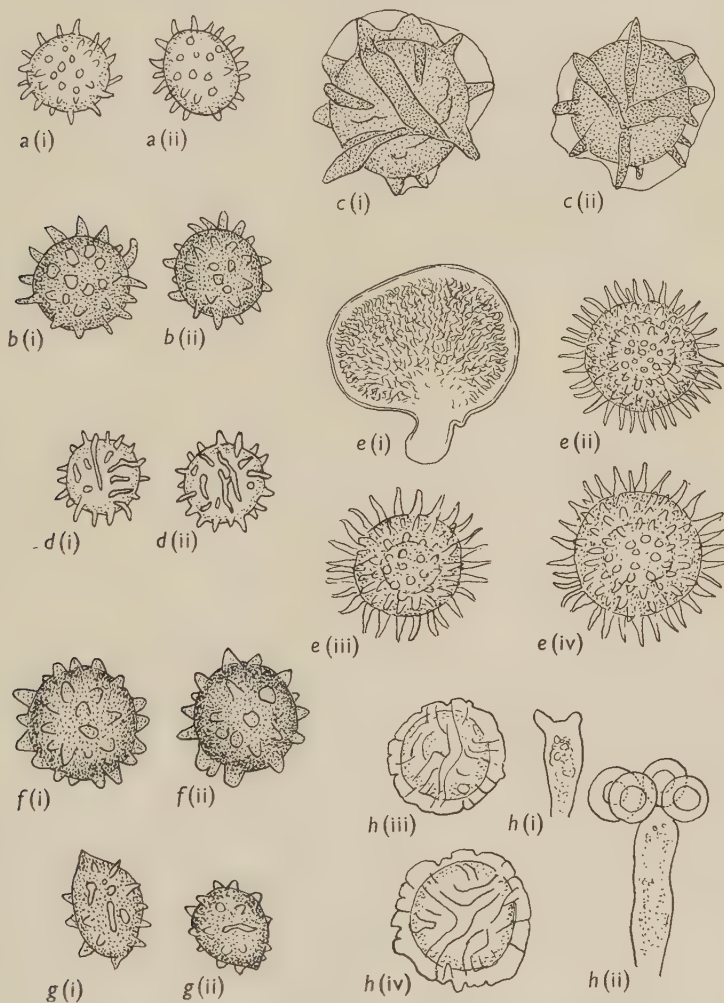


Fig. 1. (a) *Hydnangium virescens*, basidiospores. (b) *H. echinulatum*, basidiospores. (c) *Archangeliella beccarii*, basidiospores. (d) *A. malaiensis*, basidiospores. (e) *Elasmomyces borneensis*: (i) L.S. fruit-body showing sterile stalk (natural size); (ii)-(iv) basidiospores. (f) *E. malaiensis* basidiospores. (g) *Stephanospora penangensis*, basidiospores. (h) *Wakefieldia striaespora*: (i) young basidium with two short sterigmata; (ii) nearly mature basidium with four spores; (iii)-(iv) basidiospores showing gyrose plate-like thickenings of episore. Basidia, $\times 550$; Basidiospores, $\times 1300$.

collection.) *Peridium*: smooth, apricot-orange, not separable, 200-300 μ thick, extreme outer layer composed of densely interwoven pigmented hyphae, inner layer of hyaline, periclinal hyphae interspersed with wider

lactiferous hyphae. *Gleba*: concolorous, no sterile base, cavities elongate, empty, tramal plates 100μ thick, central part resembling inner peridium in structure, i.e. with lactiferous hyphae and smaller interwoven hyphae, subhymenial layer denser with somewhat cubical cells, hymenium of clavate, closely packed basidia, mature ones collapsed. *Spores*: apricot-ochraceous in mass, hyaline when seen separately under microscope, spherical, $11-13\mu$ diameter, irregularly ridged, appearing spiny in optical section, ridges transparent variable in thickness and depth (up to 3.5μ deep and 2.5μ wide), not amyloid (Fig. 1c). *Odour*: faint, fragrant.

On ground, partly covered by leaves, in bamboo forest.

Dodge & Zeller (1936) give a detailed description of Petri's material from Sarawak, Borneo. The Malayan specimen differs from this description only in having a thinner peridium and in the total instead of partial collapse of the basidia after separation of the spores. Both these differences might be due to greater maturity of the Malayan specimen and are of insufficient importance to warrant the placing of the latter in a separate variety.

Arcangeliella malaiensis Corner et Hawker sp.nov.

Receptacula depresso-globosa, peridio laevi vel subviscido, inseparabili lactescenti, gleba sordide incarnata vel subalutacea 'buff', basi sterili deficiente, dissepimentis minute lacunoso-gyrosis, tubis lacticiferis praeditis: basidia $38-46 \times 10-12\mu$, quadrispora, sterigmatibus 5μ longis: sporae $7-10\mu$, hyalinae, globosae, spinulis brevibus inter se cristis amyloideis connexis.

Single collection from Gunong Panti, Johore, 8 September 1929. (Corner No. 727, type.)

Fruit bodies: subglobose, depressed, 1.2 cm. diameter, entirely dirty pinkish buff (between Rosaceous Buff and Rosaceous Fawn of Ridgway), drying ochre-brown. *Peridium*: surface smooth, becoming slightly viscid; thin ($100-150\mu$ thick), not separable. Latex vessels present. *Gleba*: concolorous, no sterile base, minutely gyrosolacunose, tramal plates $70-100\mu$ thick, including hymenium, central part consisting of thick-walled hyphae $2-8\mu$ wide, not splitting; consistency rubbery, drying hard but tough not brittle. Latex vessels in trama as in peridium. *Basidia*: $38-46 \times 10-12\mu$, obconico-cylindric, 4 sterigmata (5μ long), basidia form compact layer with narrow pseudoparenchymatous subhymenium. *Spores*: colourless, spherical, $7-10\mu$ diameter, 1-guttate, guttae $5-6.5\mu$, short spines and connecting flanges $0.5-1\mu$ high, flanges amyloid, staining blue black in Melzer's solution often anastomosing (Fig. 1d). *Odour*: faint, slightly aromatic.

On ground among leaves in jungle.

This specimen bears some resemblance to the Chilean species, *Hydnangium thaxteri* Dodge & Zeller, as described by Dodge & Zeller (1936), but differs in the rather larger colourless spores, with fewer spines, absence of columella, thicker tramal plates and presence of latex vessels in peridium and tramal dissepiments. The absence of the columella might be due to greater maturity of the Malayan specimen, but one would expect some vestige to remain in the form of a sterile basal cushion at least. The total

differences are too great for the Malayan material to be identified with *H. thaxteri* and the presence of latex vessels suggests that it is more appropriately placed in *Arcangeliiella*.

***Elasmomyces borneensis* (Petri) Dodge & Zeller**

Single collection from Danau, Sungei Sedili, Johore, 3 August 1931. (Corner No. 735.)

Fruit-bodies: 2–2.5 cm. wide, subglobose, depressed, attenuated into short rooting portion 3–6 mm. long $\times$ 2–3 mm. wide at top. *Peridium*: smooth like kid leather, wrinkled above attachment of root, pallid white, turning deep prussian blue on bruising or cutting, 1.0–1.5 mm. thick, with denser relatively narrow outer layer and looser inner layer consisting of septate hyphae (6–9 μ wide) embedded in gelatinous matrix, continuous with tramal plates. *Gleba*: at first white, becoming fawn-drab and sub-vinaceous, cavities small but much branched and folded, filled with spores, cavities forming first at periphery and gradually extending inwards leaving more or less hemispherical sterile cushion at base of oldest specimen seen (Fig. 1e). Tramal plates 250–350 μ wide, consisting of hyphae similar to those of peridium irregularly and loosely interwoven in a gelatinous matrix. No latex vessels or sphaerocysts present. *Basidia*: mature ones collapsed and indistinguishable, young ones short, cylindrical, in a closely packed hymenial layer. *Spores*: light vinaceous brown (yellow brown in dried and pickled material), spherical, 9–12 μ diameter, with large central gutta 5–7 μ wide, echinulate, numerous long slender irregular spines (Fig. 1e (ii–iv)). Spines 2–3 μ long, 1 μ wide at base, sharply pointed, curved. Spores staining red brown with Melzer's solution but not amyloid. *Odour*: slight, of bad meat, rather soupy.

Partially buried or superficial in bare earth on the bank of river in jungle.

The Malayan material differs from the description of the type (Dodge & Zeller, 1936) in (i) the smoother peridium, which shows slightly felted surface when seen in section, (ii) in the relatively smaller columella of the mature specimen although the young specimen has a columella more nearly resembling that described by Dodge & Zeller, (iii) size and colour of spores (those of the type as described by Dodge & Zeller from dried material were 9–10 μ diameter and yellowish green in colour), and (iv) in the rapid blueing on bruising, a character which would only be visible in fresh material. All these differences are of minor importance and are such as would result from the difference between fresh and preserved material, or from the type specimen being perhaps somewhat younger than the larger Malayan specimen.

***Elasmomyces malaiensis* Corner et Hawker sp. nov.**

Receptacula depresso-globosa, breviter stipitata, peridio albedo, tactu cyanescenti, gleba albida dein obscure brunnea, gelatinosa et venulis albidis cyanescentibus traversa, basi sterili praedita, locellis parvis: sporae 10 μ , globosae, spinulis brevibus conicis paucis praeditae.

Single collection from Sungei Ketil, Kelantan, June 1931. (Corner No. 743.)

Fruit-bodies: 2.0–3.5 cm. wide, globose, depressed, substipitate, stem 5–6 mm. high. *Peridium*: white, turning deep inky blue, then fuscous black on bruising, matt surface, drying yellow-fawn. *Gleba*: white, then drab brown, drying brown-black, gelatinous, traversed by fine veins which turn pale blue on cutting. Sterile base continuing stem, translucent white, turning deep inky blue on cutting. Cavities indistinct in dried material, small, stuffed. *Basidia*: not observed. No young material available. *Spores*: spherical, 10μ diameter, dark brown, short conical, wide-based spines, few and irregular (Fig. 1f).

This specimen does not closely resemble any species described in Dodge & Zeller's (1936) monograph. The specimen is poorly preserved, but there is no indication of gleba becoming exposed around stipe, therefore it is best placed in the genus *Elasmomyces*.

***Stephanospora penangensis* Corner et Hawker sp.nov.**

Receptacula depresso-globosa vel reniformia, ochracea subtomentosa, basi depresso e rhizomorpha brevi oreunda, peridio tactu haud discoloranti, lamellis tramae continuo, gleba vinaceo-brunnea et subtiliter venulosa, locellis parvis compressis: basidia bispora: sporae $9 \times 7\mu$, obscure purpureo-brunneae, irregulariter fusiformes vel pyriformes, spinulis brevibus vel cristis sparsis praeditae.

Single specimen from Penang Hill at height of 2000 ft., 29 May 1941 (Corner No. 747, type.)

Fruit-body: globoso-depressed to reniform, 3 cm. diameter, ochraceous, felted; short branched rhizomorph attached in slight depression on under side. *Peridium*: ochraceous, brownish on top, not changing colour on bruising, drying dull ochre, minutely scurfy, subtomentose of closely felted hyphae, continuous with tramal plates. *Gleba*: dull vinaceous umber, drying dark brown-black, finely veined, flesh pale ochraceous, not changing colour on bruising. Veins not visible in dried material. Trama of curved, not much branched hyphae. Partitions, about 240μ wide, chambers small, not compressed, filled with spores. *Basidia*: 2-spored. *Spores*: irregular top-shaped or pyriform with tendency to pointed 'stalk', about $9 \times 7\mu$, dark purple brown, sparsely covered with short conical, hyaline spines or flanges $1\text{--}2\mu$ deep (Fig. 1g). Not amyloid. *Odour*: strong, of rotting oranges.

On earth bank in jungle.

The shape of the spores suggests that this specimen is best placed in the genus *Stephanospora* although the spines are less regularly arranged than those of the spores of *S. carotaecolor*. The peridium is thicker than that of the type species and is persistent.

***Wakefieldia* Corner et Hawker gen.nov.**

Basidiis bi- vel quadrisporis, sporis globosis, coloratis, episporio compacto sculpturato, punctato- excavato vel lincis arcuato-striato, haud echinulato. Typus: *Wakefieldia striaespora* Corner et Hawker sp.nov., Singapore.

***Wakefieldia striaespora* Corner et Hawker sp.nov.**

Receptacula depresso-globosa laevia, minute subtomentosa, albida dein flavida, rhizomorpha brevi fibrillosa, oreunda, peridio firmo, a gleba haud distincto, gleba albida dein vinaceo-incarnata, basi sterili deficiente, locellis parvis, irregulariter gyrosis:

basidia $40 \times 8 \mu$, quadrispora, sterigmatibus brevibus: sporae $10-11 \mu$, fusco-purpureae, globosae, crasse tunicatae, lineis arcuatis subtiliter figuratae.

Collected Reservoir Jungle, Singapore, 18 January 1931, type; 4 November 1931. (Corner Nos. 734, 749.)

Fruit-bodies: $1.2-1.9$ cm., globose, somewhat depressed, firm, smooth but minutely and closely cottony-felted under a lens, white, becoming slightly yellowish with age, not changing colour when bruised, short rhizoidal fibril from the base. *Peridium:* $0.5-0.8$ mm. thick, firm, subcartilaginous outer layer, felted but firm, slightly thicker inner layer, not distinctly marked off from gleba. Hyphae $5-20 \mu$ wide, thin colourless walls. *Gleba:* white, then vinaceous pink, traversed by small gyrose lacunae, irregularly arranged, no sterile base, firm rather dry, not becoming rubbery or gelatinous. *Basidia:* clavate, about $40 \times 8 \mu$, 2 to 4-spored, soon collapsing, sterigmata very short (Fig. 1h (i) and (ii)). *Spores:* fuscous purple under microscope, globose $10-11 \mu$ diameter, marked with faint, irregular curving 'ascoboloid' lines (Fig. 1h (iii) and (iv)), i.e. epispore laid down in thin plaques shaped as sectors, wedges, etc. Wall very thick, large central gutta $5-6 \mu$ wide. *Odour:* sour, foetid and fairly strong, like immature puff balls.

At first hypogeous then breaking through ground and becoming superficial, on a bare bank by jungle path.

This species cannot be included in any existing genus owing to the distinctive plate-like sculpturing of the spores.

B. *Spores more or less spindle-shaped or pyriform, smooth or variously wrinkled or warted*

Chamonixia mucosa (Petri) Corner et Hawker comb.nov.

Hymenogaster mucosus Petri, *Malphigia*, **14**, 130, 1900

Gautiera mucosa (Petri), Dodge & Zeller, *Ann. Mo. bot. Gdn*, **21**, 625-708, 1934.

Collected: Gardens Jungle, Singapore, July 1929 (Corner No. 736); Botanical Gardens, Singapore, 3 September 1935; Reservoir Jungle.

Fruit-bodies: 2.0×1.5 cm. subglobose, depressed pulvinate, white, discolouring blue-green when bruised, surface subtomentose, minutely silky, felted. Attached by a narrow base from which several small white fibrils arise (Fig. 2a (i)). *Peridium:* well developed (650μ thick), closely interwoven hyphae projecting at surface, distinct from gleba but not readily separable. *Gleba:* white then purplish-fuscous, firm, becoming subgelatinous and rubbery, eventually deliquescing. Drying hard and dark red brown. Cavities narrow, lacunose, labyrinthiform. Small discoid sterile base, 3.4×2 mm., rapidly discolouring lilac pink, then blue-green or indigo when cut and exposed to air. Trama variable width ($150-300 \mu$), hyphae ($3-5 \mu$ wide), colourless with mucilaginous walls, loosely interwoven and anastomosing to give loose network (Fig. 2a (ii)). *Basidia:* $16-25 \times 9-11 \mu$, clavate, with 4 short sterigmata ($1.5-2 \mu$ long) (Fig. 2a (iii), (iv)). *Spores:* fuscous, spindle-shaped and subacute, 1-guttulate (gutta $4-6 \mu$) or with 2-3 smaller guttae, smooth, enclosed in a yellowish firm mucilaginous sheath or utricle standing out from spore wall in four

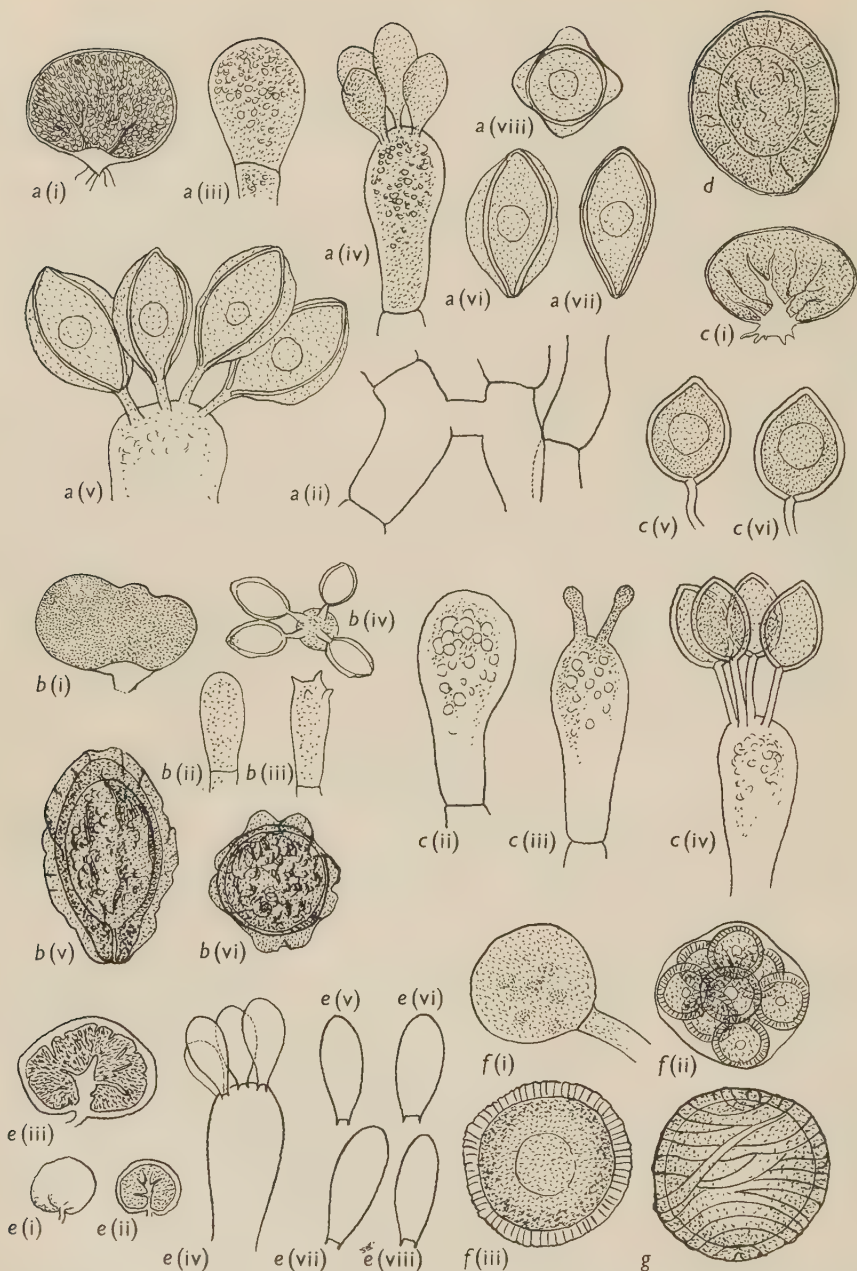


Fig. 2. (a) *Chamonixia mucosa*: (i) L.S. fruit-body showing sterile base (natural size); (ii) anastomosing cells of trama, $\times 1300$; (iii)–(v) development of short clavate basidia; (vi) basidiospore with ribbed thickenings of episporium seen in optical section; (vii) spore in different position with ribs not showing; (viii) spore seen end on showing four ribs, $\times 1300$. (b) *C. octorugosa*: (i) L.S. fruit-body, showing sterile base (natural size); (ii)–(iv) basidia, $\times 550$; (v), (vi) basidiospores ((vi) end on, showing 8 ribs), $\times 1300$. (c) *Dendrogaster cambodgensis*: (i) L.S. fruit-body (natural size); (ii)–(iv) developing basidia; (v), (vi) basidiospores, $\times 1300$. (d) *D. aurantius*, mature basidiospore, $\times 1300$. (e) *Hysterangium purpureum* var. *malaiense*: (i) young fruit-body; (ii), (iii) L.S. young and older fruit-bodies showing central columella (natural size); (iv), basidium with four immature sessile basidiospores; (v)–(viii) mature basidiospores, $\times 1300$. (f) *Elaphomyces singaporensis*: (i), (ii) young and nearly mature asci; (iii) mature ascospore, $\times 1300$. (g) *E. carbonaceus*, mature ascospore, $\times 1300$.

longitudinal ridges $1-2\mu$ deep (Fig. 2a (vi) and (vii)) giving spore a square appearance in end view (Fig. 2a (viii)). Spore dimensions, excluding sheath, $15-16 \times 7-9\mu$. *Odour*: rather strong of dill seed, like *Hydnum graveolens*.

Among leaf mould, half buried in jungle.

The description given by Dodge & Zeller (1934) of *Gautieria mucosa* (Petri) Dodge & Zeller collected by Petri in Borneo fits the Malayan material closely. The latter has rather larger basidia which may be due to greater maturity of the specimens or to the fact that Dodge & Zeller's description is based solely on dried material. The last fact would also explain why these authors do not refer to any discoloration of fresh material when bruised. The absence of a central columella in the Malayan material may also be due to its maturity. Unfortunately no young specimens are available.

The presence of a very definite peridium and the small closed glebal chambers suggest this species should not be classed in *Gautieria*. The latter genus should be limited to those species which, like the type species *G. morchellaeformis*, have no peridium when mature and in which development is by infolding of the periphery so that the hymenium lines a complex system of folds which are in communication with one another. Our specimens resembled *Chamonixia caespitosa* Rolland in the rapid blue discoloration when cut or bruised, the relatively short stout basidia, the ridged spores and the general globose form of the white fruit-body. Young material of the type species, *C. caespitosa*, collected in Norway in 1950 (Lange & Hawker, 1952) showed a definite short stalk but this did not increase in size and in mature specimens was inconspicuous and not unlike the sterile base of the present specimen. It is therefore proposed to transfer the latter to the genus *Chamonixia*.

***Chamonixia octorugosa* Corner et Hawker sp. nov.**

Receptacula depresso-globosa subsessilia subtomentosa albido-cinerea, tactus ordine purpurascens, peridio tenui, gleba sordide subpurpurea, maturitate gelatinosa, basi sterili discoideo praedita, locellis numerosis minutis: basidia clavata, sterigmatibus 4, gracilibus, $7-8\mu$ longis: sporae $18-20 \times 10-11\mu$, obscure rufo-brunneae, ellipsoideae, crasse tunicatae, quadrigeminato-rugosae, appendiculo basali praeditae.

Single fruit-body from Fraser's Hill, Pahang, 17 May 1930. (Corner No. 748, type.)

Fruit-body: subsessile, 2.2 cm. wide $\times$ 1.6 cm. high, subhemispherical, depressed, externally adpressedly subtomentose, greyish white, becoming dingy fuscous purple on bruising and drying (Fig. 2b (i)). *Peridium*: thin, no true pseudoparenchyma, hyphae $3-7\mu$ wide, colourless, septate, branched, loosely interwoven, those on outside fuscous brown forming a felt. *Gleba*: pale fuscous purple, becoming gelatinous (rubbery in pickled material) with numerous minute cavities, sterile base pallid white, discoid, 9×3.5 mm. (Fig. 2b (i)), no columella or sterile veins. Tramal hyphae $3-7\mu$ wide, colourless, septate, branched, loosely interwoven. Hyphae of base similar. *Basidia*: mostly collapsed, a few younger ones clavate, tapering to base, with 4 slender sterigmata $7-8\mu$ long (Fig. 2b (ii)-(iv)). *Spores*: dark chocolate brown, ellipsoid, very thick walls thickened into longi-

tudinal ridges usually in 4 pairs but sometimes anastomosing, $1.5-2\ \mu$ deep (Fig. 2b (v) and (vi)). Spore dimensions without ridges $18-20 \times 10-11\ \mu$. Definite but small claw-like appendiculus at point of attachment to sterigma. *Odour*: slight, like that of *Hymenogaster tener*.

Half buried in humus at soil level near waterfall at 3500 ft. above sea level.

This specimen is obviously near the last (*Chamonixia mucosa*) and its dark ridged spores approach those of *C. caespitosa*. The shape of the 4-spored basidia is strikingly similar in all three species.

***Dendrogaster cambodgensis* Patouillard**

Collected: Angsi Forest Reserve, Negri Sembilan, 28 June 1930; Bukit Timah, Singapore, 23 February 1931; Sungei Nipa, Kemaman, Trengganu, 24 June 1932. (Corner Nos. 737-8, 745.)

Fruit-bodies: subglobose $1.5-4.0\ \text{cm.}$, seated on a small longitudinally plicate discoid cushion about $1.5\ \text{mm.}$ thick $\times 5-9\ \text{mm.}$ wide. Smooth but surface minutely adpressedly silky in places, bright golden yellow, the discoid base tawny orange, tawny orange mycelial fibrils spreading into the soil. On surface of ground resembling a bright orange sessile *Scleroderma* (water colour in Corner's collection). *Peridium*: thin, about $0.5\ \text{mm.}$ thick, firm, not disintegrating. Hyphae mostly $2-4\ \mu$ wide but sometimes up to $6\ \mu$, mucilaginous walls, compactly interwoven at surface, yellow oily or granular contents; not forming pseudoparenchyma. Yellow colour due to amorphous granular masses encrusting outer projecting hyphae. *Gleba*: watery-gelatinous but firm becoming rubbery at maturity, pallid white, then chocolate umber, minute cavities, veins radiating from the discoid base. *Basidia*: subclavate, $16-20 \times 8.5-9.5\ \mu$, with 2 to 4 long cylindric sterigmata ($4-12 \times 1.5\ \mu$) breaking away and remaining attached to spores. *Spores*: dark, tawny ferruginous, smooth, rounded at base, pointed at apex, thick-walled, $10.5-12.5 \times 7.7-8.5\ \mu$, single large gutta ($4.5-5\ \mu$), without mucilaginous sheath (Fig. 2c (i)-(v)). *Odour*: not strong but foetid and pungent.

On surface of ground below humus layer.

Agrees with Patouillard's (1923) description.

***Dendrogaster aurantius* Corner et Hawker sp. nov.**

Receptacula depresso-globosa, peridio laevi aureo-flavido vel aurantio, ad basim incrassato, gleba purpureo-brunnea gelatinoso-elastica: sporae $18 \times 14\ \mu$, obscure rufo-brunneae, apice rotundato, basim versus paulo attenuatae.

Collected: Cameron Highlands, Pahang, at approximately 5000 ft., 6 August 1934. (Corner No. 744, type.)

Fruit-bodies: globose, depressed $1.0-8.0\ \text{mm.}$ in diameter. *Peridium*: golden yellow to bright orange, thickened pad at base, smooth surface, drying dull yellow. *Gleba*: purple-fusous, rubbery-gelatinous, drying dark brown, hard. Material badly shrunken, cavities and hymenium indistinguishable. *Spores*: dark red-brown, rounded at apex, slightly tapering to point of attachment about $18 \times 14\ \mu$. Wall very thick ($2.5-3.0\ \mu$) thinner at base (Fig. 2d). *Odour*: more or less of pea soup.

Partially immersed in soil in jungle.

Hymenogaster viscidus Masee & Rodway

Single specimen collected Gunong Panti, Johore, 16 April 1931. The specimen has since been lost, but full notes of fresh material are available and these agree closely with Dodge & Zeller's description of *H. viscidus*.

Fruit-body: sessile, suglobose, 2.1 cm. wide, externally matt, nearly smooth, bistre-drab. Consistency firm, hard, cheesy, not deliquescent. *Peridium*: rather thick, about 1 mm., pallid white in section, composed of more or less inflated hyphae 7–15 μ wide, colourless, thickened and agglutinated walls 1–3 μ thick. Near the surface, hyphae arranged in compact palisade of short cells at right angles to surface, central layer of longer cells more or less interwoven and with slightly thicker walls, inner layer of narrow (3–6 μ wide) interwoven hyphae. *Gleba*: chocolate umber, firm not deliquescent, small chambers, narrow white veins, no sterile base. Veins or tramal plates arising from inner layer of peridium and of similar structure with walls of hyphae, agglutinated so that there are no visible air spaces, hence the firm cheesy consistency. *Basidia*: all collapsed. *Spores*: ellipsoid, slightly flattened on inner side, yellow-brown under microscope, walls slightly thickened and punctate, contents subgranular without guttae, 11–15 $\times$ 6.5–8 μ , with short hyaline appendage (remains of sterigma at base), 2.3–1.5 μ . *Odour*: very faint.

Under leaves in jungle.

C. *Spores lanceolate, smooth: hymenium forming over surface of complex peripheral folds of the central columella*

Hysterangium purpureum Zeller et Dodge
var. **malaiense** Corner et Hawker var. nov.

A typo differt peridio et gleba pallidiori, sporis minoribus 8–12 $\times$ 4–5 μ .

Collected: Bukit Timah, Singapore, 23 February 1931, type; Mandai Road, Singapore, 17 February 1931; Jalan Kutu, Bukit Timah, Singapore, 26 January 1941. (Corner Nos. 739–741.)

Fruit-bodies: globose, depressed, sometimes lobed and irregular, sessile, 0.9–3.5 $\times$ 0.7–1.7 cm., externally white or tinged olivaceous, slowly becoming dull raspberry red on bruising, nearly smooth but minutely cottony or very slightly scurfy in places under a lens, often puckered or umbilicate at base, attached by a short white rhizoid (0.5–1 mm. wide), firm or rather hard (Fig. 2e (i)–(iii) (water colour in Corner's collection). *Peridium*: firm, hard, forming a compact layer (0.5–1 mm. thick) of rather thick-walled hyphae (5–20 μ wide), apparently no air spaces, forming an irregular pseudoparenchyma. White in section, becoming rufescent on bruising as with the outside. Readily separable from the gleba. *Gleba*: fuliginous-olivaceous, rather light coloured, irregularly lacunose, traversed by translucent greyish, subgelatinous veins arising from basal central main vein or columella. Remaining firm, not becoming soft and gelatinous. Collection 741 differing slightly in purplish fuscous gleba and bluish fuscous grey veins. *Basidia*: clavate, tapering to base about 25 $\times$ 7 μ . Usually 4-spored; sterigmata very short, spores almost sessile (Fig. 2e (iv)). *Spores*: ovoid, elongated, smooth, rounded apex, small claw-like remains

of sterigma at base, pale buff under microscope. $8-12 \times 4-5 \mu$, often with 1 to several small guttae in Collections 739 and 740, no guttae in 741 (Fig. 2*e* (v)–(viii)). *Odour*: faint, sweet, as over-ripe blackberries, but also rather fishy or like a phalloid.

Gregarious on surface of ground under humus layer in jungle.

Differing from the type in paler colour of peridium and gleba and in smaller size of spores.

Even the smallest specimens were nearly mature but the structure suggests that, as with *H. clathroides* (Rehsteiner, 1892), *H. stoloniferum* (Fitzpatrick, 1913) and *H. nephriticum* (Hawker, unpublished observation), the gleba has developed by a complex infolding of the periphery of the columella. In view of Fischer's (1908) and Fitzpatrick's (1913) views that the Clathraceae may have evolved from *Hysterangium* or related forms it is of interest to note that the fresh material showed the following phalloid characteristics: (1) characteristic pale olivaceous-fuliginous colour of spores and gleba (also found in other species, e.g. *H. nephriticum*), (2) the shape of the spores, (3) the firm pseudoparenchymatous peridium, (4) the central columella which may correspond to the stem of a phalloid, (5) the characteristic smell.

II. ASCOMYCETES, Plectascales

A. ELAPHOMYCETACEAE. Mature fruit-bodies containing powdery mass of dark spores. Asci globose, evanescent.

Elaphomyces singaporensis Corner et Hawker sp. nov.

Receptacula depresso-globosa atrata laevia, cortice sinapicolori dense investita, peridio tenui subcarbonaceo, gleba excavata: asci $30-36 \mu$, globosi, octospori: sporae globosae, fuligineo-olivaceae, strato externo columnis prismaticis instructo, hyphis capillitii intermixtis.

Collected: Garden's Jungle, Singapore, 20 February 1931, type; Mandai Road, Singapore, 17 May 1931.

Fruit-bodies: globose, depressed, 1.0–1.3 cm. dull black, smooth, closely invested in mustard yellow cortex (0.3–0.8 mm. thick), composed of compact mass of hyphae, $3-5 \mu$ wide, slightly thickened, yellow and minutely rough walls, yellow mycelial strands passing into surrounding humus. *Peridium*: thin and subcarbonaceous, black. *Gleba*: hollow, flesh pallid white, peripheral zone, 1.5–2.5 mm. wide, of loose cottony hyphae giving a spongy texture. *Asci*: in a few small fuliginous greenish blue clusters on inside of flesh and projecting into cavity, or sometimes as similarly coloured continuous layer bordering cavity, subglobose, about $30-36 \mu$ wide, 8-spored. *Spores*: fuliginous-olivaceous in mass, 18–14 (av. 13) μ diameter, mixed with capillitium hairs, globose, appearing rough through splitting apart of prismatic columns of outer layer of wall, small gutta 1–2 μ wide (Fig. 2*f* (i)–(iii)).

Gregarious, buried to depth of 2 inches in loose soil beneath humus in jungle.

***Elaphomyces carbonaceus* Corner et Hawker sp. nov.**

Receptacula sessilia, globosa, compressa vel sublobata, verrucis subpyramidalibus papillata, atrata, peridio strata externo verrucosa tenui et strato interno carnosio crasso praedito, gleba obscure purpureo-brunnea albido-venulosa pulverulenta: asci 40μ diam., subglobosi, octospori: sporae $15-16.5\mu$, purpureo-brunneae, globosae, lineis elevatis annularibus subtiliter figuratae.

Collected: Bukit Timah, Singapore, 10 March 1940, type; 13 December 1940.

Fruit-bodies: 1.5–3.5 cm. wide, sessile, subglobose or flattened and slightly lobed, wholly papillate with fine subhexagonal, subpyramidal warts, 0.3–0.6 mm. wide, dull coal-black. *Peridium*: warty thin outer layer, carbonaceous, coal-black, brittle or rather woody, and thick pale brown, rather fleshy inner layer. *Gleba*: when fresh, purplish fuscous, powdery, white-veined, often becoming hollow in centre, drying dark purple-brown, powdery and contracting from wall. *Asci*: 40μ wide subglobose, saccate. *Spores*: $15-16.5$ (av. 16) μ wide, globose, purple brown, with fine annular and shortly gyrose raised lines, large gutta in fresh spores (Fig. 2g).

On ground under leaf mould in forest.

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HAUSTORIA OF *PHYTOPHTHORA INFESTANS* AND SOME OTHER SPECIES

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(With Plates 8 and 9, and 11 Text-figures)

Photographs with explanatory drawings illustrate the appearance of haustoria formed by the invading mycelium of *Phytophthora infestans* in certain varieties of potato. In the diseased tuber these haustoria have a characteristic thickening which can be removed by treatment: in the leaf they bear no such thickening. The narrow entry of the haustorium through the host cell-wall is shown. In both tuber and leaf the sporadic occurrence of haustoria is interpreted as due in part to the influence of the host cell. In the mesophyll the frequent occurrence of a couple of haustoria in the fork of the branching mycelium is related to the check to the growth of the hypha as it comes up against a cell. Short lateral hyphal branches, 'diverticula', sometimes penetrate the narrow inter-cellular spaces of leaf and axis. No intracellular hyphae have been observed. It is claimed that haustoria are not essential to *P. infestans* for absorption: they occur in some cells of some plants of some varieties. A list of the varieties of potato examined is given.

A survey of the papers written between 1875 and 1950 on recognized species of *Phytophthora* leads to the conclusion that haustoria are formed by some species and not by others. A list of species for which haustoria have been recorded is given.

I. *PHYTOPHTHORA INFESTANS* IN POTATO

INTRODUCTION

On 25 April 1947, at a conversazione of the Association of Applied Biologists, slide preparations and drawings of haustoria of *Phytophthora infestans* in potato were exhibited by members of the Botany School of Royal Holloway College, and some of the drawings were later published by Butler & Jones (1949, fig. 256). Indeed, the investigation carried out at R.H.C. owes its origin to a request from Dr Jones for a drawing of haustoria of *P. infestans*. He had explored the literature, without success, for an illustration of these for the book which he was then preparing. We, alas, had nothing for him, but, out of a natural curiosity, we began to seek for haustoria in potato tubers, and were lucky, as we realized later, with the first tuber we examined: a tuber of variety Majestic supplied by Dr Joan Moore. So we were encouraged to explore further. A year or two later we heard that Miss Ann Godwin, at the Botany School, Cambridge, was demonstrating haustoria of *P. infestans* in potato leaves, and at a meeting of the British Mycological Society on 12 March 1949, when we again demonstrated these haustoria, we invited her to join in our demonstration. The descriptions given below of the haustoria in the leaf are in part hers, and are included here with her kind permission.

This short statement, of our findings and hers, has been too long delayed, and even now it does not claim to be anything more than a description of what the haustoria look like when found in the tissues of

some varieties of potato with blight. But judging by the interest shown in our demonstrations it is clear that the majority of plant pathologists are no more familiar with these haustoria than were we when Dr Jones drew our attention to them and pointed out that the information in the literature is scanty. Even in papers which take account of them, either they are poorly illustrated, or they are looked upon with suspicion and called haustorioid hyphae, or they are frankly misinterpreted, the term haustorium being used for an intracellular hypha, or for the 'diverticulum' (Butler & Jones, 1949, fig. 255 E) which is a short and usually intercellular lateral branch or branch system of the invading mycelium.

HISTORICAL ACCOUNT

It does not surprise us to find that de Bary had seen and figured the haustoria of *P. infestans*. His slide preparations and original drawings are preserved in the British Museum (Natural History), London. Two preparations are of sections of sprouting potato tubers, and haustoria can be found in them. He said they were rare (1863), and later (1876), when he had made a study of haustoria of the different species of *Peronospora*, he noted their comparative rarity in *Peronospora* [*Phytophthora*] *infestans*. He reported that in the leaf the hyphae simply press against the wall of the host cells, and that in petiole, stem and tuber short branches form in the intercellular space and some penetrate the host cell-wall. But he often searched for them in vain. After describing the haustoria of certain species of *Peronospora*, he writes (de Bary, 1863, p. 34): 'Le *P. infestans* Mont. est la seule espèce qui, selon nos observations, est le plus souvent dépourvue de suçoirs. Son mycélium ne fait que serrer sa membrane ténue contre les cellules du tissu qu'il habite. Du moins, il en est ainsi quand le parasite envahit les feuilles. Dans le parenchyme compacte des pétioles, des tiges et des tubercules de la pomme de terre, on voit quelquefois des rameaux courts du mycélium déprimer les parois des cellules. Parfois ces rameaux sont assez nombreux, et l'on en trouve même qui perforent les membranes des cellules; mais fréquemment on les cherche en vain.' In the same paper he remarks that a mature haustorium is almost always surrounded by a thick sheath-like layer which belongs to the protoplasm of the host cell. He sowed spores on potato leaves and found the mycelium among the mesophyll cells but did not report haustoria there.

Saccardo (1888, p. 237) says of *P. infestans*: 'haustoriis semper fere destitutis'.

Mangin (1895) figures haustoria in the leaf and seems to have found them fairly general. He observed four main types of haustorium in the *Peronosporales* and described those of *Phytophthora infestans* as slender, simple suckers of variable length within the cell cavity.

Delacroix (1903, 1904) illustrates from tuber tissue under the name 'suçoir' two different things. In his fig. 1 he illustrates the haustorium as described by de Bary and Mangin, albeit without the thickening or sheath-like layer described by de Bary, which he says he has never seen: 'je n'ai, de plus, jamais réussi à apercevoir de double membrane sur la surface de suçoir'. In his fig. 2, 'Sc. suçoir simple, Sc.r. suçoir ramifié' he illustrates both a haustorium (Sc.) and a diverticulum (Sc.r.) which is

intracellular. He admits this is an exceptional 'suçoir' and the only one of its kind he has seen: 'je n'ai jamais vu qu'une seule fois (fig. 2) un suçoir très nettement ramifié dans la cavité d'une cellule'. Unfortunately, Jones, Giddings & Lutman (1912, fig. 53) chose this diverticulum as their one illustration of a haustorium: 'haustorium from mycelium in potato penetrating host cell. Drawing from a preparation courteously furnished by Dr Delacroix.' This drawing is not so carefully made as is the one made by Dr Delacroix from the same cell for his fig. 2.

Butler (1918, p. 281) writes: 'Only haustoria enter the cells. In the tubers they are common and easily seen, simple or branched, finger-shaped, clavate or roundish, and often surrounded by a cellulose sheath, formed by the cell protoplasm in an attempt to shut off the parasite. In the leaves, the haustoria are much harder to detect, filiform, and seldom provided with a sheath, while in the stem they seem to resemble those of the tuber.' He gives a small clear drawing of haustoria in the mesophyll.

Mlle M. B. Löhnis (1922, figs. 14, 15) figures the mycelium in tuber tissue but no haustoria.

Szymanek (1927*a*) made a thorough study of the appearance of *P. infestans* in the tissues of the various organs of the potato, and reported his findings in two papers, one of which (1927*b*) has much enlarged figures which are, however, not very clear. He describes the intercellular hyphae as wide, branched and palmate, and the haustoria as claviform, even filiform, not noticeably pinched at the base but narrowed there forming a club. He says the membrane of the haustorium is much thicker than that of the hypha and that it stains intensively. To quote his own description of the haustoria: '...claviformes, cunéiformes et même filiformes. Ils ne sont pas notablement étranglés à leur base, mais plutôt rétrécis lorsqu'ils sont en forme de massue... La membrane cellulaire présente autour de la base des suçoirs un épaississement qu'on pourrait appeler ourlet cicatriciel. Cet épaississement se colore plus intensément que le reste de la membrane cellulaire.' With reference to Mangin's work, he comments on the figures of fine haustoria in the leaf, pinched at the base '...effilés à leur extrémité et étranglés à leur base'; and remarks that while Mangin found penetrating haustoria in the leaf quite commonly, de Bary had, on the other hand, found them rarely: 'On apprit que la pénétration du mycelium par les suçoirs à l'intérieur de la cellule est un fait générale, tandis que de Bary, au contraire, estimait que c'était là un fait rare.'

Schilberszky (1928) states he found 'no characteristic haustoria but, especially on the hyphae in the tubers, short excrescences and rudimentary hypha-branches no longer than the width of the hypha... such sporadic elevations of the hypha (mycelium inflatum) were close together, sometimes in twos, threes or fours, mostly on the same side of the piece of hypha and adhering firmly to the host cell... which appeared pressed in by them'. A piercing of the host cell was not observed and he calls them 'haustorioid hyphae', comparing them with organs found in epiphytic fungi.

Butler & Jones (1949, fig. 6) give a drawing from a slide by Gonzalez and Lamont of the mycelium of *P. infestans* in the leaf of potato showing haustoria in some of the mesophyll cells.

MATERIAL

The parasite. As the diseased tubers used in this investigation were collected here and there from clamps and fields, the strain of *P. infestans* is unknown. Miss Ann Godwin in her artificial infection of potato leaves used a culture of *P. infestans* known, in the Commonwealth Potato Collection of fungi, as No. 13, which belongs to the A group. It was grown in fresh detached King Edward potato leaflets and subcultured every week.

The host. The special interest of this study has been the sporadic occurrence of haustoria within the parasitized host cells. In only certain cells of certain tubers of certain varieties were they found. But not all varieties of potato have been examined, and the ones examined have been given unequal attention. We can only give our experience which was as follows.

Haustoria have been found frequently in the tubers of varieties Arran Banner, Majestic and Up-to-date; occasionally in Epicure and Gladstone; rarely in Golden Wonder. They have been sought and not found in the tubers of Arran Pilot and Doone Star.

Haustoria have been found occasionally in the leaves of King Edward and Majestic; rarely in Arran Banner and Gladstone. The first two of these were used by Miss Godwin for artificial inoculation. They have been sought but not found in the leaves of Arran Bard, Arran Pilot, Arran Peak, and Golden Wonder.

Negative results must not be taken as final. It is possible that search may reveal them in other plants: in tubers at other stages of maturity or in leaves earlier or later in the season.

METHODS

Tuber. Hand-sections were taken at the edge of the infected region and examined: (a) in the living state, (b) after fixation in 4 % formalin and staining with cotton blue in lactophenol, (c) after treatment with iodine in potassium iodide and concentrated sulphuric acid. The preparations have been preserved in glycerine and have improved with time.

Aerial shoot. Longitudinal sections were taken of stem and petiole and treated as above. The leaves were mounted whole or with one epidermis removed, and cleared. The preparation of the leaf of variety Majestic, which was made by Miss Godwin (Text-figs. 6, 8 and 9; Pl. 9, fig. 2) was made by the following method. Leaflets were artificially infected by spraying the under surface with a very concentrated suspension of spores of *P. infestans* No. 13. After about 3 days the leaflet was killed with boiling water, decolorized with methylated spirit, cleared in 1:1 mixture of phenol and chloral hydrate, stained in cotton blue, mounted in lactophenol and sealed.

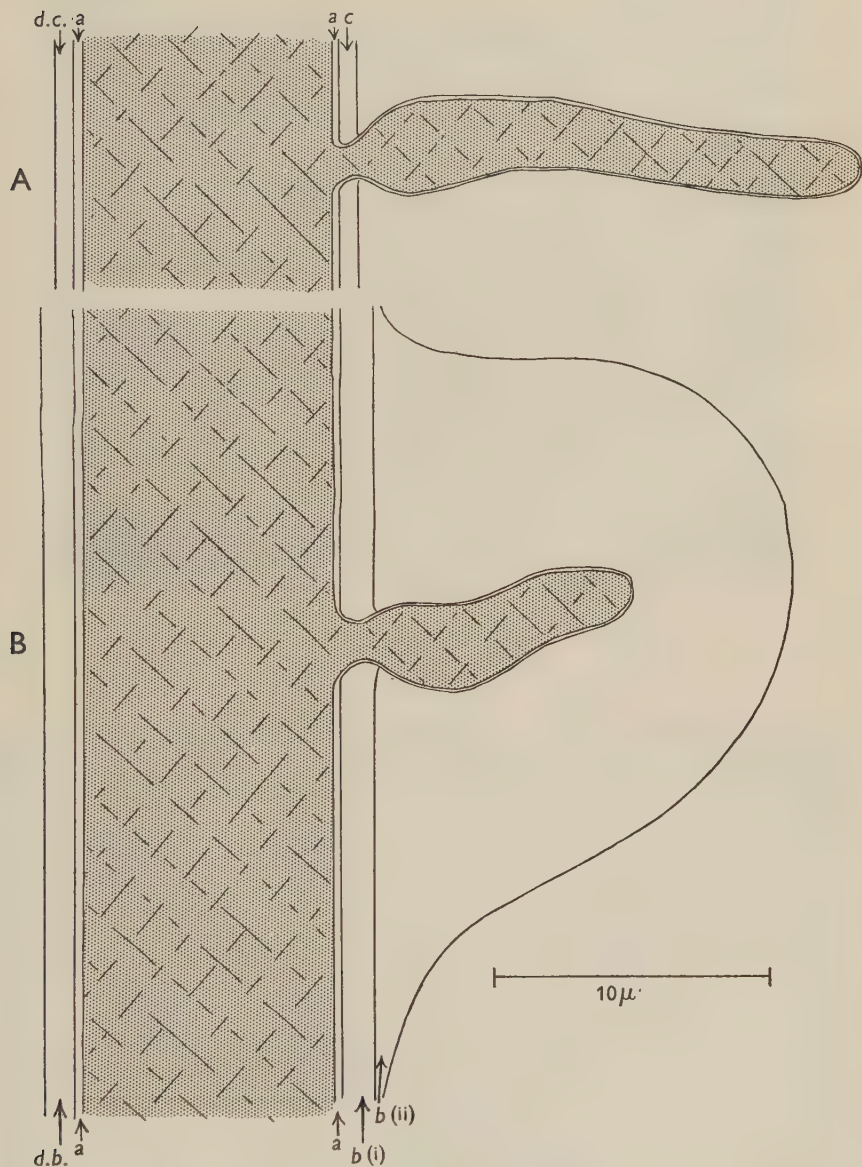
DESCRIPTION OF HAUSTORIUM IN POTATO

The haustorium is small and simple. It is elongate and, in the tuber especially, rarely longer than the width of the hypha which bears it (about 8μ). It is straight or curved, rarely coiled or branched. Its diameter is no more than 1 or 2μ , and the width at the base, where it has penetrated the host cell-wall can, with difficulty, be seen to be narrower still (Text-figs. 4, 8 and 9; Pl. 8, fig. 2). Haustoria may be developed upon

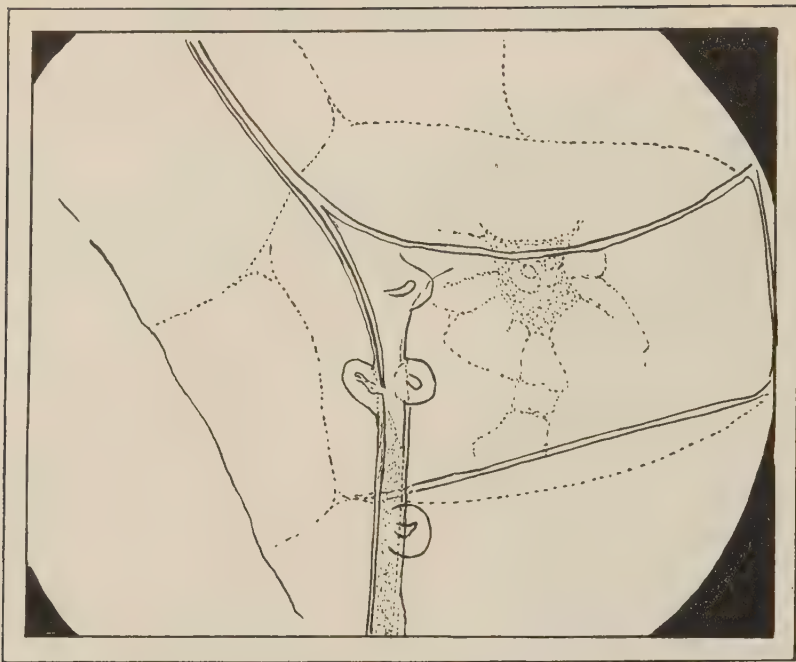
the mycelium penetrating the tissues of leaf, aerial stem and tuber (as in Arran Banner) or only locally in one region or another. The mycelium retains its vitality for months in the tuber, and the observations recorded in this paper are mainly from over-wintered tubers, even from those diseased areas which have been isolated by a layer of cork (formed from a periderm initiated in the healthy tissue around), and thus are probably observations of haustoria of long standing. On the other hand, the descriptions of haustoria in the leaf are of newly formed ones.

The haustorium in the tuber. The haustorium as observed in sections of mature tubers which are obviously infected with blight bears a thickening which, presumably, has been deposited upon it by the host cell which it has penetrated (Text-figs. 1-4; Pl. 8, figs. 1, 2). Because of this, haustoria are more readily detected in the tuber than in the stem and leaf. Nevertheless, even here some trouble must be taken to find them for they are infrequent and sporadically produced (Text-fig. 7). First the region of infection of the tuber must be determined, i.e. the region where the branched hyphae of *P. infestans* are to be found running between the cells of the tuber. This region is indicated to the naked eye by a brown discoloration. Microchemical tests reveal a lignification of the tissues here: there is no longer the positive reaction for cellulose which is given by the healthy tissues around. Thin sections taken at the edge of such a region of infection and treated with iodine and sulphuric acid, show, by contrast, the diseased region of the tuber: for whereas the still healthy, and the freshly attacked parts, turn blue, the parts where the old hyphae are, both hyphal walls and host cell-walls remain firm and golden brown. It is in this border-line region that haustoria must be sought. They are not to be found in every infected tuber: they are developed only in certain varieties of potato, and then only in some of their tubers. In these, moreover, they are produced more in some cells than in others which suggests that the host cell is a causal agent in the formation of haustoria by the hyphae (see Text-figs. 5, 7; Pl. 9, fig. 1). If a section taken at this border-line region of infection be mounted in cotton blue in lactophenol, the haustoria become more evident because the thickening now appears as a pale blue halo. Another useful stain for the thickening is Hoffman's blue which colours it a greenish yellow. In sections which have been treated previously with iodine and sulphuric acid, and kept for two or three years in glycerine, the thickening is less evident, having been dissolved or rendered transparent (Text-figs. 5, 7; Pl. 9, fig. 1). By this time, too, the starch grains are invisible, which is a great help to observation. In fresh sections the starch grains are a problem and various methods have been tried to remove them, but at the edge of a thin hand-section they fall out of the cut cells, leaving the hyphae and cell-walls clear, when haustoria, if present, can be observed without difficulty.

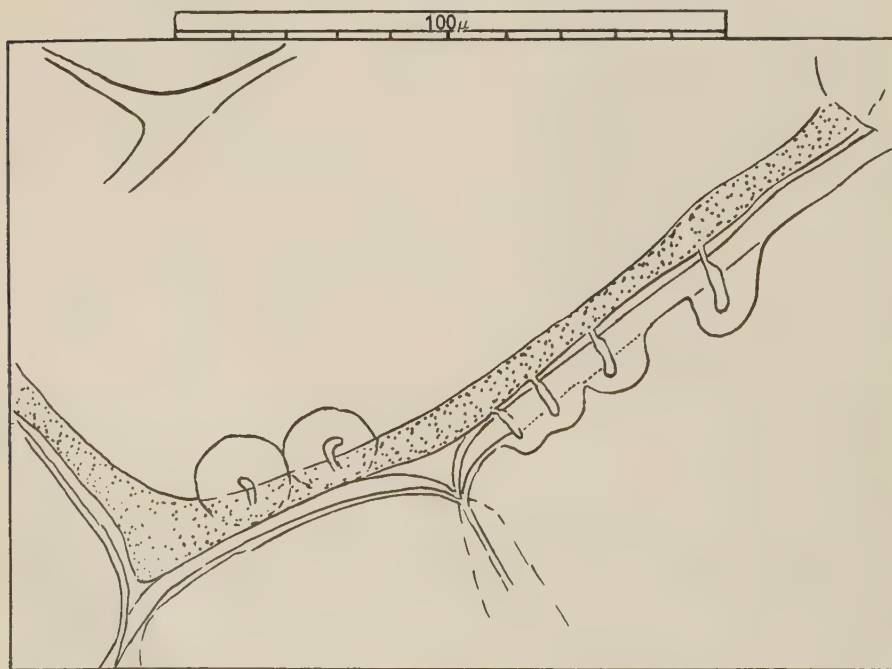
Text-fig. 7 shows a length of mycelium from a tuber of variety Up-to-Date in a three-year old preparation in which everything had disappeared except the hyphae with their haustoria and those parts of the host cell-walls in contact with them and now very thin. The thickening upon the haustorium had gone too. It would seem that the hyphal wall, and the wall of the parasitized cell firmly attached to it, are almost indestructible.



Text-fig. 1. Diagram to illustrate the interpretation given in this paper of the wall between a hypha (with a haustorium) of *P. infestans* and the potato cell it has penetrated. A, haustorium in mesophyll. B, haustorium in tuber. *a*, wall of hypha, of fungus chitin; *b* (i), original wall of tuber cell, now chemically changed and very resistant; *b* (ii), a later-formed wall-layer upon the haustorium, referred to in this paper as *the thickening*; *c*, wall of mesophyll cell, of cellulose; *d.b.* and *d.c.*, wall of adjacent cell in either tissue, the hypha having replaced the middle lamella.



Text-fig. 2. Explanatory drawing of Pl. 8, fig. 1 of a hypha between tuber cells, both of which have been penetrated by haustoria. These cells are exhausted of protoplasm, but there appears in the photograph, at a lower focus, a living cell with a nucleus. (Variety Up-to-Date. Hand-section taken from living material, fixed in 4 % formalin, mounted in glycerine.)



Text-fig. 3. Explanatory drawing of Pl. 8, fig 2 of a portion of a hypha (stippled) with six haustoria: four in side view in one tuber cell; and two in end view in another tuber cell. (Variety Up-to-Date. Tuber over-wintered in a clamp. Hand-section taken in April from the living material, fixed in 4 % formalin, stained with Hoffman's blue, mounted in glycerine.)



Fig. 1.

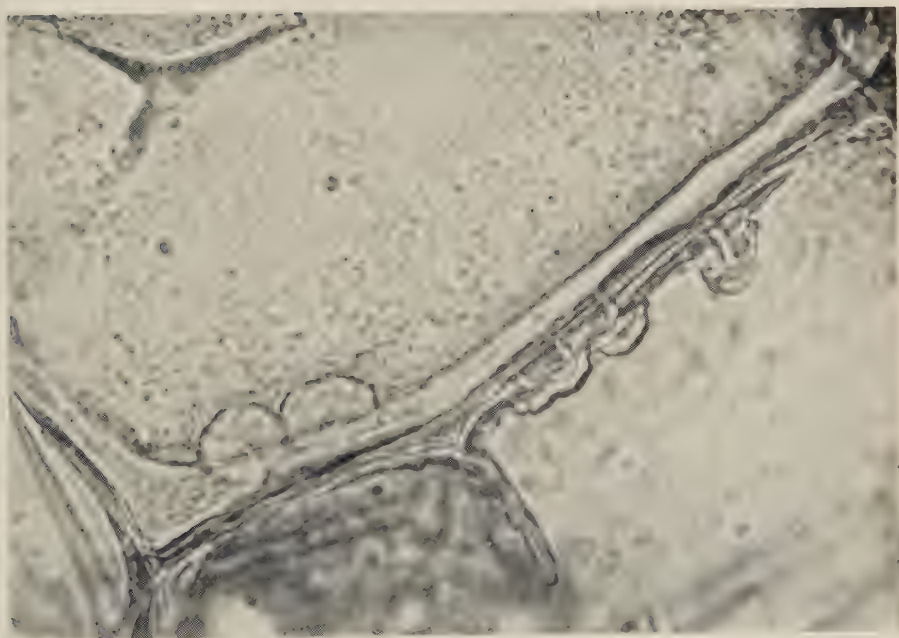
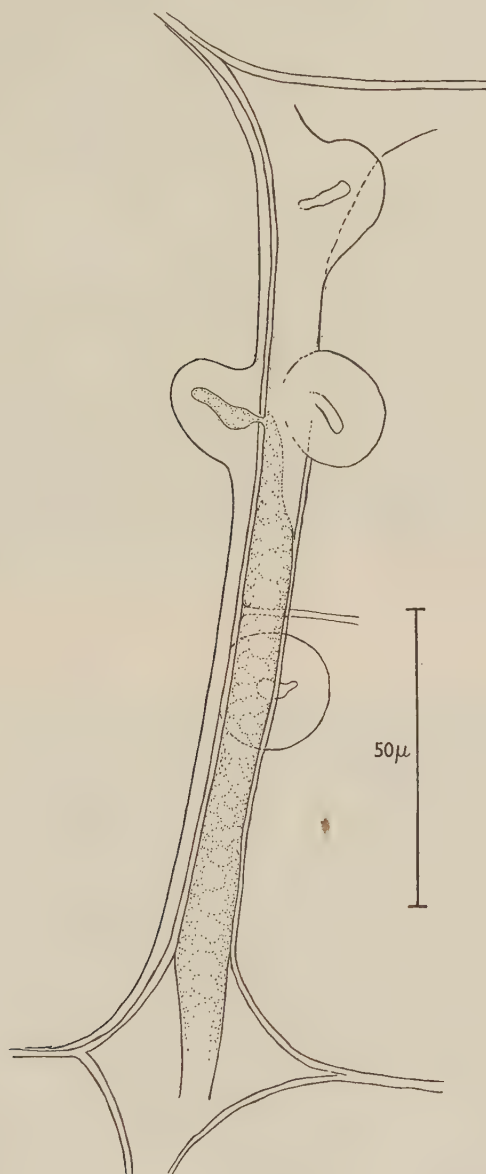


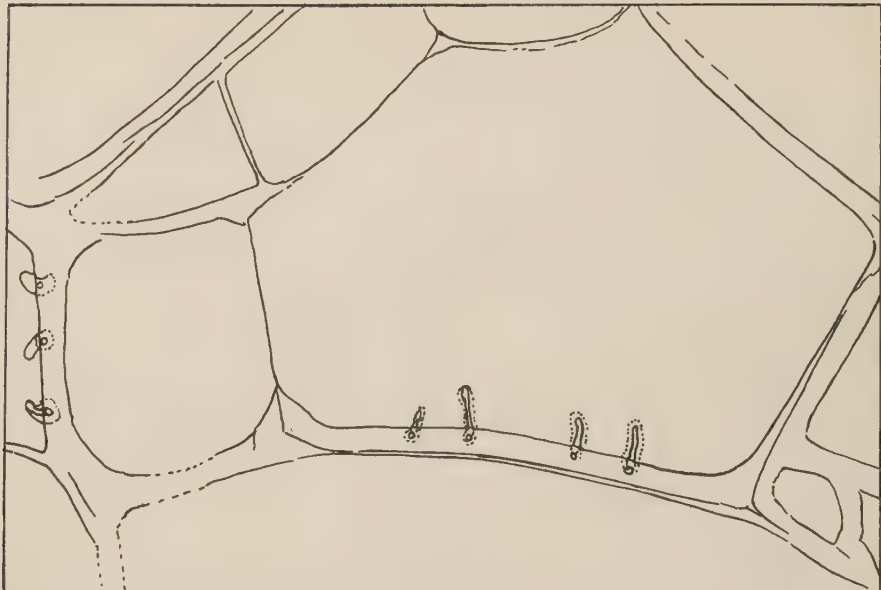
Fig. 2.

But the preparation has now, after eight years, become too delicate to handle and is almost invisible.

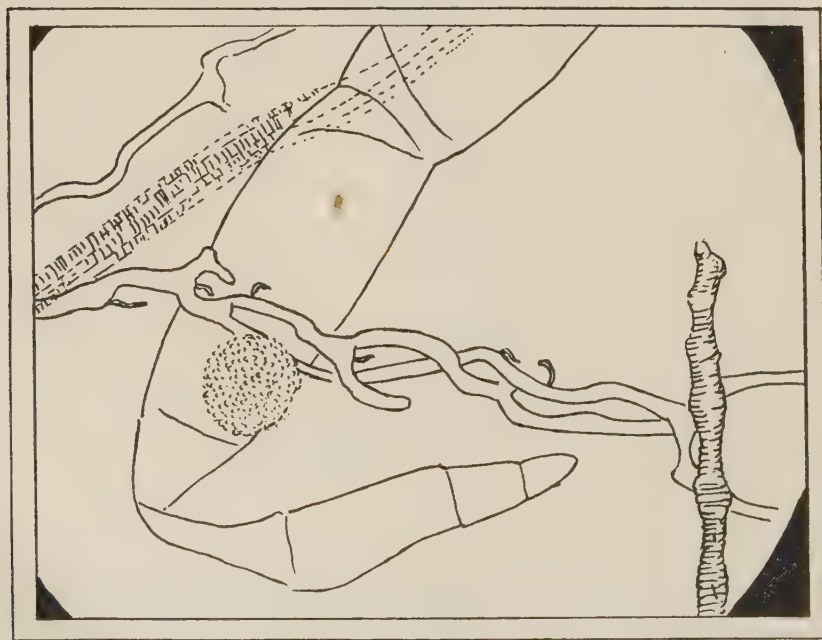


Text-fig. 4. Detail of the four haustoria shown in Text-fig. 2, one of which shows the narrow point of entry. The hypha bearing them is stippled where it has been caught in the section.

Text-figs. 2-5; Pl. 8, figs. 1, 2; Pl. 9, fig. 1, show hyphae penetrating between tuber cells. Text-figs. 2, 3 and Pl. 8, figs. 1, 2, show the haustoria as in the living state, with the characteristic thickening. In Text-figs. 5, 7 and Pl. 9, fig. 1, the thickening has been removed.



Text-fig. 5. Explanatory drawing of Pl. 9, fig. 1 of a hypha with haustoria, after severe treatment (see below), the thickening upon the haustoria is almost dissolved away. (Variety Majestic. Hand-section of tuber taken from a clamp in January. Section then left for some time in concentrated sulphuric acid after being in iodine in potassium iodide, washed in water, stained with cotton blue in lactic acid, washed again and kept in glycerine for 6 years.) (Note. This photograph is of the hypha illustrated in Butler & Jones, *Plant Pathology*, London (1949), but taken after the preparation had, at a later date, been remounted the other way up, and so this appears as a mirror image of the earlier drawing.)



Text-fig. 6. Explanatory drawing of Pl. 9, fig. 2 of the mycelium running in the mesophyll. Two vein endings and an epidermal hair which have survived the treatment give scale to the photograph. The mycelium bears two diverticula and a few haustoria. (Variety Majestic. Leaflet artificially infected by *P. infestans* strain A and incubated at 18–20°C. After 70 hours leaflet killed with boiling water, decolorized methylated spirit, cleared in 1 : 1 mixture of phenol and chloral hydrate, stained cotton blue, mounted in lactophenol, sealed in gum-damar-beeswax compound.)

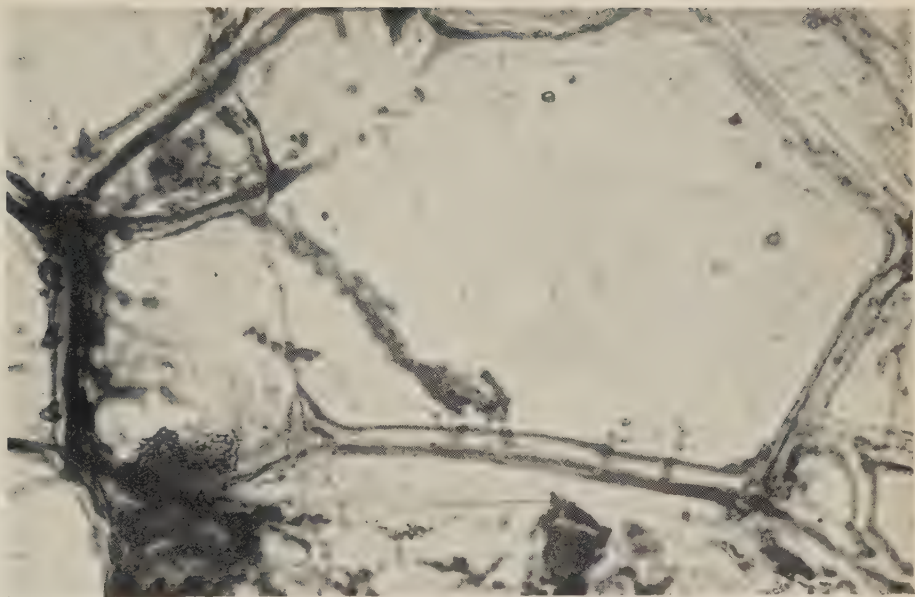


Fig. 1.

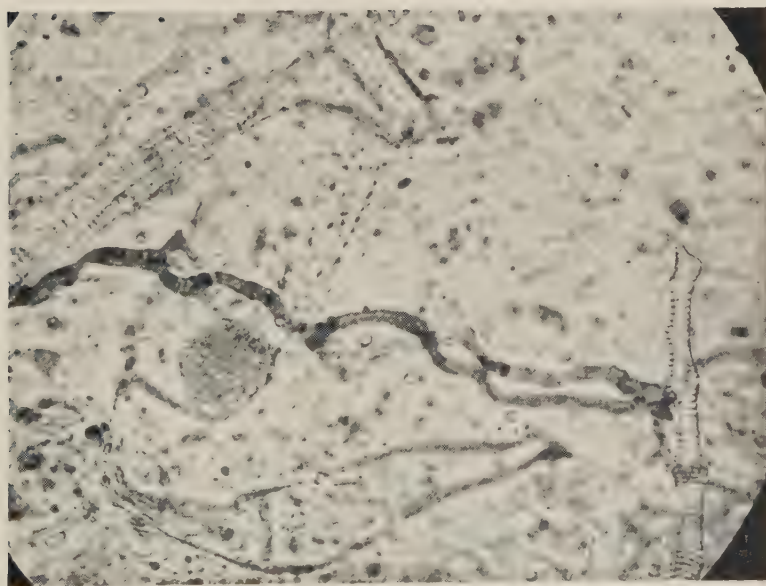
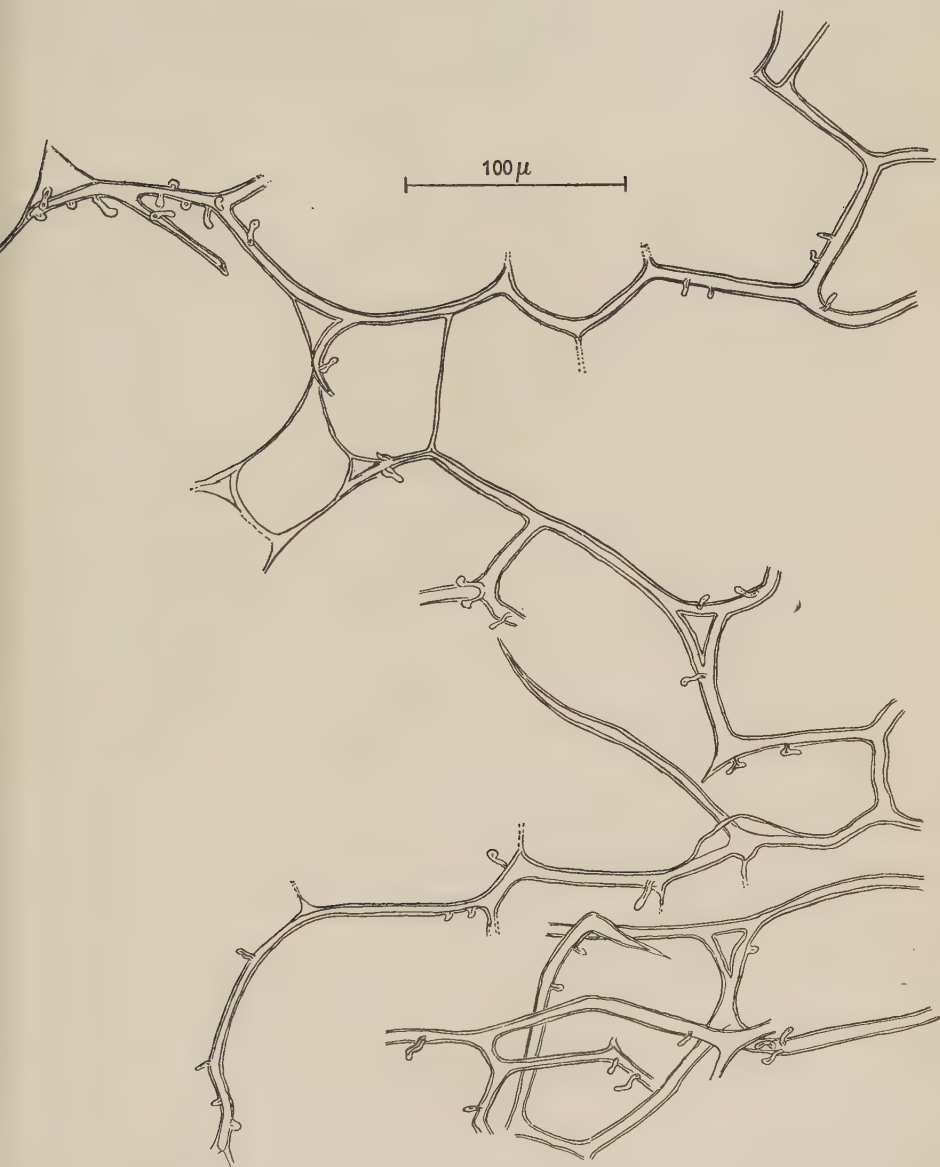
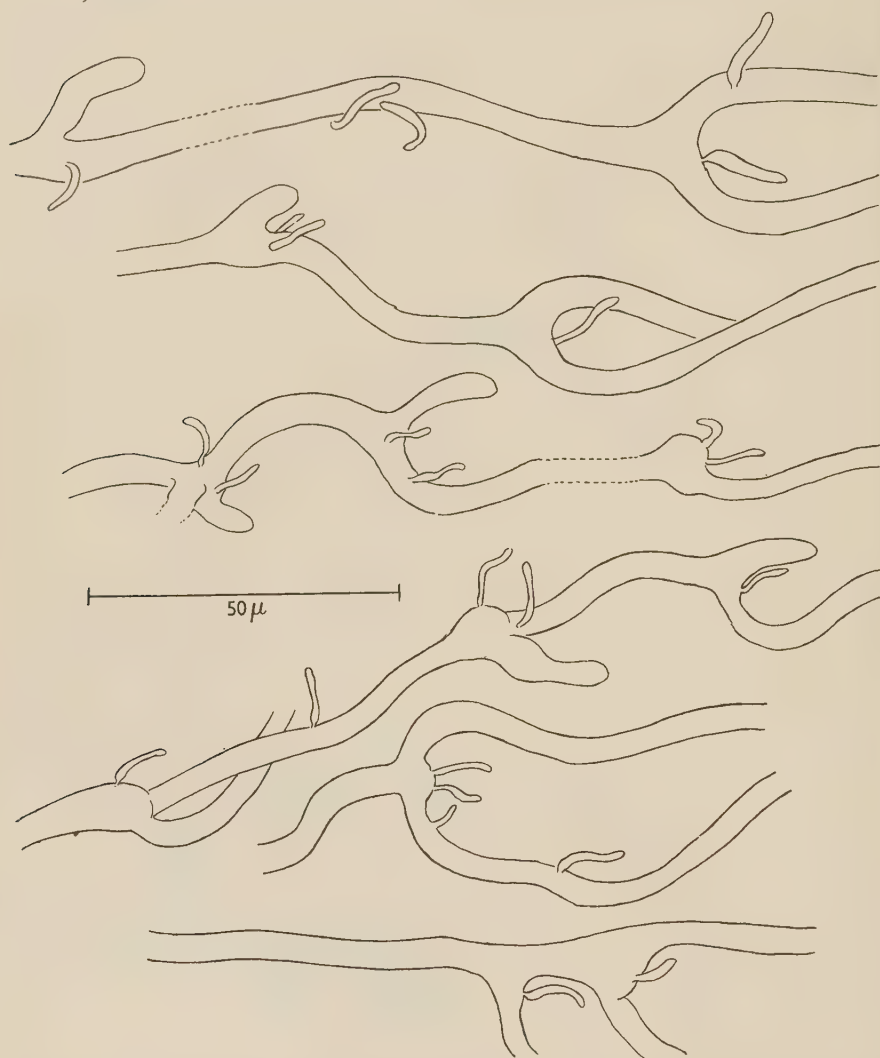


Fig. 2.



Text-fig. 7. A drawing to scale of a stretch of mycelium, running between tuber cell-walls. Treatment with acids has rendered it clearly evident among the almost vanished tuber cells. The infrequency of haustoria and the irregularity of their distribution is evident. (Variety Majestic, for treatment see Text-fig. 5. The section when cut bore cells with protoplasm and starch grains, and the mycelium was difficult to sec. Now all that remains of these cells is the part of the walls which adjoins the hyphae.)

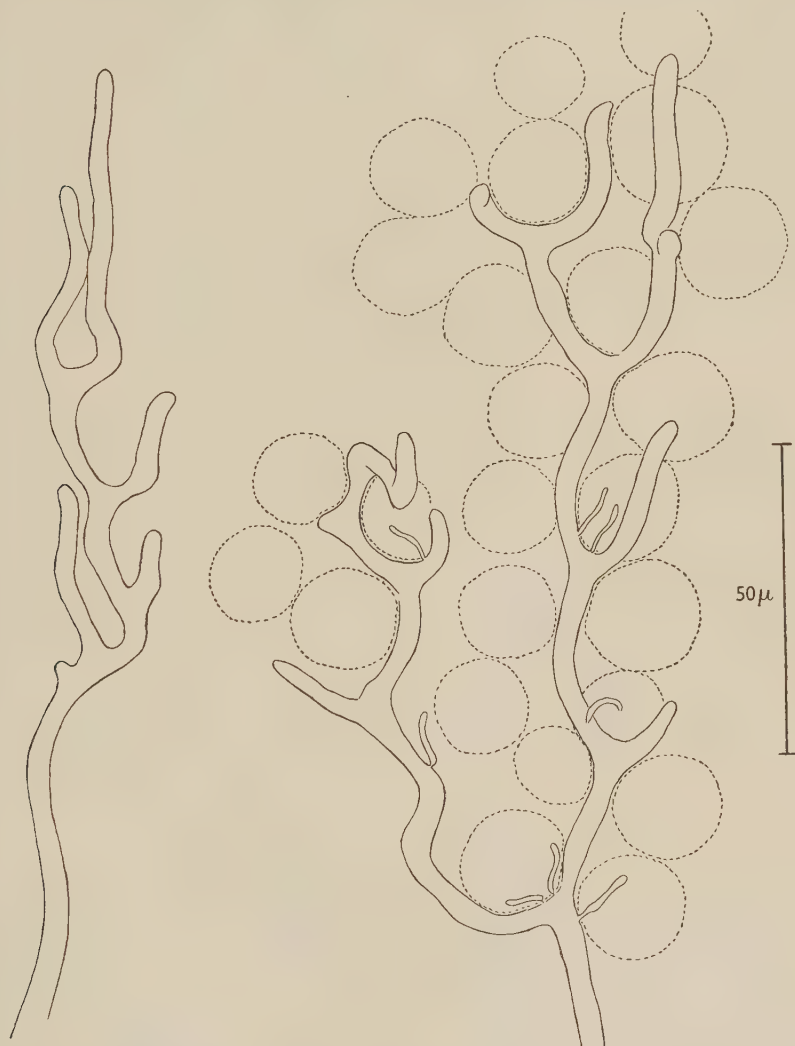
It is probable that the haustoria in the tuber, as described here, have been not only mature but possibly already out of action: the absorption having been checked by the thickening. It is more than likely that young and active haustoria are thin walled. In the aerial shoot they are, and remain, thin walled.



Text-fig. 8. Detail of mycelium in the mesophyll. When a hypha comes up against a cell it forks, i.e. branches around it, and in the fork one or two haustoria form and penetrate the surrounded cell. They show, frequently, a narrow entry. (From the same leaflet as Text-fig. 6.)

The haustorium in the leaf. Observations were also made on haustoria in the aerial shoot by Miss Molesworth in the leaf of Arran Banner, and Miss Osterburg made drawings of diverticula in the stem of King Edward.

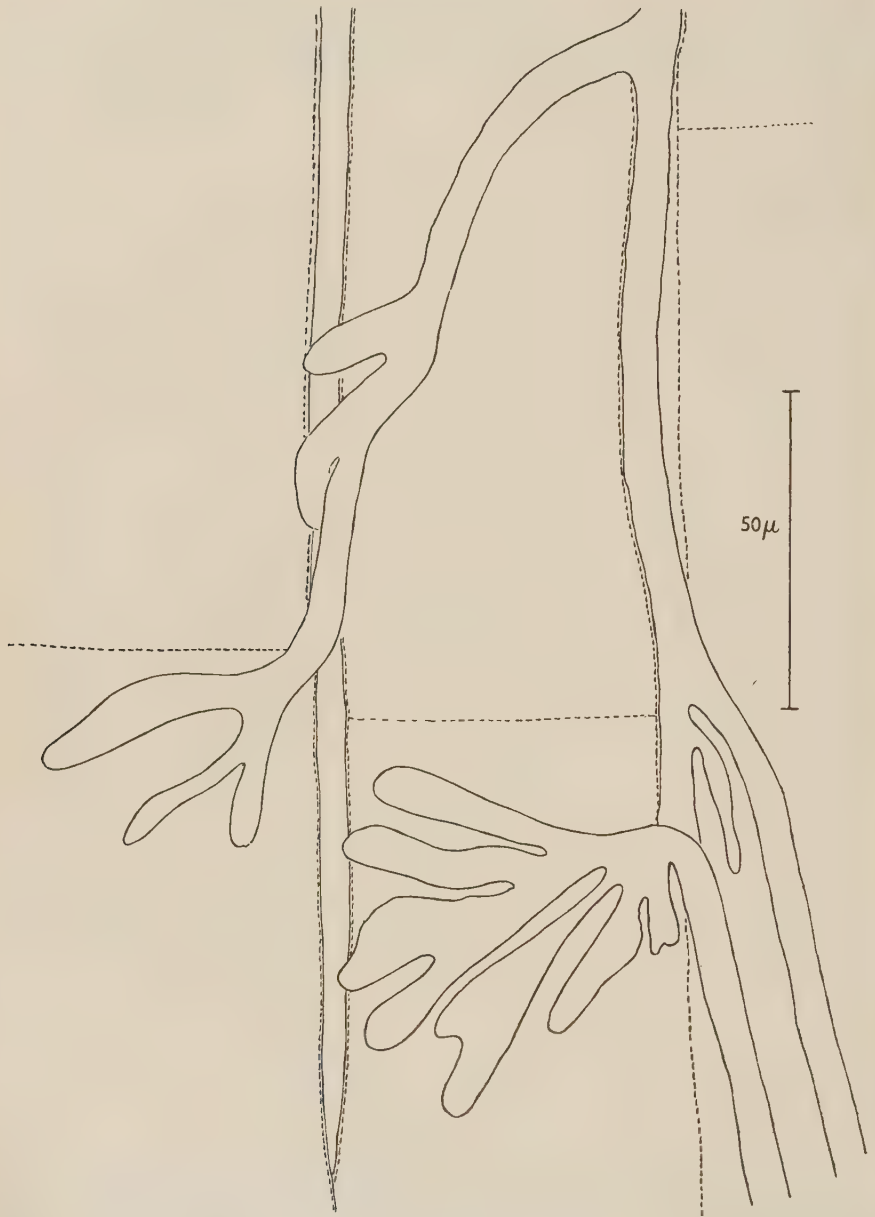
Meanwhile, Miss Godwin was working in Cambridge on the leaves of varieties King Edward and Majestic, examining the rapidly growing hyphae in the mesophyll and observing haustoria. It is from a report of



Text-fig. 9. Further detail of mycelium in the mesophyll. Two, recently and quickly grown, mycelial branches: the one on the left has no haustoria as yet: the one on the right bears haustoria. Both have the characteristic short lateral branches which are developed in the palisade mesophyll: the 'diverticula'. Wall of some of the palisade cells indicated by a dotted line. (From the same leaflet as Text-fig. 6.)

her work (1950) that the following quotations are made with her kind permission:

Spores were picked up on a damp paint brush from a sporang leaflet and wiped lightly over small areas of detached leaflets, stems and petioles... Small entire leaflets, or pieces about 1-2 cm. square, were cleared at regular intervals after inoculation...



Text-fig. 10. Diverticula in the stem, just below the stripped off epidermis. Here the lateral branches are compound and palmate. Wall of invading hypha indicated by a continuous line, wall of host cells by a dotted line. (Variety King Edward, fixed 4 % formalin, cotton blue in lactic acid, mounted in glycerine. (Note. This drawing appears in *Terminology in Phytophthora*, Mycological Paper No. 30, Commonwealth Mycological Institute, Kew.)

using the clearing agent described by Wild, 1947... In this way cleared material could be examined under a microscope in less than 10 minutes after its removal from the incubation chamber. The material was stained with cotton blue and mounted in lactophenol or with aniline blue as described by Wild... In cleared pieces of leaf tissue, mycelium was first seen 50 hours after inoculation, but was not visible in every piece of tissue examined. Only 72 hours after inoculation was it possible to be sure of finding mycelium. Using entire leaflets, more satisfactory results were obtained, and stages of infection after 30 hours could be found regularly in most leaflets examined. This discrepancy could be explained, since a larger area of entire leaflet was examined and therefore the possibility was greater of identifying a restricted amount of fungus. In spite of continuous efforts no visible sign of infection has been seen in material incubated for less than 30 hours... The mycelium was observed to consist of non-septate hyphae which ramify in the intercellular spaces of the leaf. Abundant branching, usually dichotomous, but occasionally trichotomous, occurs whenever a hypha comes in contact with a cell... Between the two branches of a dichotomy there often emerges one or two slender filiform structures about one-third the diameter of the mycelium. Similar structures also arise from unbranched mycelial threads especially in the vicinity of veins. These are the haustoria which often penetrate cells to an extent of at least half the cell diameter... entirely similar to those figured by Mangin (1895).

Text-figs. 6, 8 and 9 are drawings made from a slide preparation kindly loaned by Miss Godwin. Text-fig. 9 is of a length of mycelium in the leaf which should be compared with Text-fig. 7. Text-fig. 8 gives in greater detail the form and position of the haustorium as developed in the mesophyll, and Text-figs. 6, 8 and 9 show the short hyphal branches or diverticula which the mycelium develops in the mesophyll. Text-fig. 10 shows the fan-like lateral branches or diverticula given off by the quickly growing mycelium in the haulm of variety King Edward. The preparation from which this drawing was taken was made by Miss Osterburg by removing the epidermis of the stem and exposing the mycelium running in the intercellular spaces of the outer cortex.

Intracellular hyphae were not observed and have not previously been recorded for *P. infestans*, except for the 'suçoir ramifié' of Delacroix.

NATURE AND OCCURRENCE OF HAUSTORIA

If the definition of haustorium given by Ainsworth & Bisby (1945) be accepted, viz. 'a special hyphal branch, especially one within a living cell of the host, for the absorption of food', there is no need for the refinement suggested by Schilberszky (1928) in the use of the expression: 'haustorioid hypha'. Moreover, they are not branches comparable to a finger of a glove, for they appear to have made a small hole in the wall and to have expanded within the cell, and then, in the tuber, to have been thickened. Their occurrence is sporadic and it is not obvious what induces their formation. Schilberszky observed that in the tuber they arise in groups, in twos and threes, mostly on the same side of the piece of hypha. This we too have observed (Text-fig. 5; Pl. 9, fig. 1) and have attributed it to the influence of the host cell, some cells permitting of penetration by haustoria more readily than others. Miss Godwin has called attention to the fact that, in the leaf, haustoria are frequently formed in pairs where the mycelium forks. Is this because there is here a temporary check to growth as the hypha comes up against a mesophyll cell, and

branches to pass round it? The haustorium in the leaf is longer and more slender than in the tuber.

Of the effect upon the formation of haustoria of such factors as the season of growth, the age of host or parasite, the age of the variety of the host or of the strain of the parasite, we have nothing exact to report. De Bary's two preparations which show haustoria are of *sprouting* potato tubers. Miss Molesworth noted that she found haustoria in tubers of variety Up-to-Date only after they had been sliced and put into dishes, and from which sporangiophores had then grown. It is possible that we have been fortunate in finding haustoria because the tubers we examined had often been stored for a while in the laboratory. Miss Godwin obtained an abundance of haustoria in leaflets which had been inoculated only 70 hours previously.

One can readily accept the apparently contradictory statements of such reliable observers as de Bary, Mangin and Butler, by assuming that their observations were made under different conditions, or by assuming that they examined different varieties of potato. Even in one variety, even in one plant, tubers and leaves may not behave in the same way. Again one suspects that varieties change their character: becoming more productive of haustoria as they become more susceptible to blight. The variety Majestic was listed with resistant forms in a report of the Ministry of Agriculture 1919: in 1944 it was reported susceptible. This again might explain why de Bary and Saccardo found haustoria rare. May the presence of haustoria be taken as an indication of susceptibility? Is it possible that some modern varieties of potato have as one of their characteristics a proneness to induce haustoria in *P. infestans*? In other words, are haustoria to be found more frequently to-day than a century ago, when de Bary, that most exact of observers, said they were rare?

THE TUBER CELL-WALLS AND THE THICKENING UPON THE HAUSTORIUM

The tuber cell-walls where hyphae run between them replacing the middle lamella become very resistant to acids, as resistant as the hyphal walls themselves. The thickening, however, is a further deposit laid down on the host cell side, which can be removed as described above. Dastur (1913), with Mangin's observations in mind, expected this to be callose but failed to find callose constantly present. Butler (1918) and Szymanek (1927 *a* & *b*) call it cellulose. It has been assumed that the thickening is an aid to absorption, but clearly it is not essential, for it is not present on haustoria in the leaf. And what is the young and active haustorium in the tuber like? How soon does the thickening form? De Bary, the pure morphologist, says it belongs to the protoplasm of the host cell. Butler says it is formed 'by the cell protoplasm in an attempt to shut off the parasite'. A causal morphologist might suggest that it is an accumulation of waste material after the passage of nutrient through the wall. In appearance, chemical reactions, staining properties, and this position in the path of late transference of nutrient, it suggests a comparison with other thickenings and 'plugs' found in plants and fungi. It is significant that where there has

been an exceptionally heavy flow of food through the cell-wall of plants and the hyphal wall of fungi, there accumulates a deposit, called 'callose' by botanists, which gradually stops transport. A number of examples come to mind: the callus on the sieve plates of sieve tubes of vascular plants; the plugs in those pollen tubes which are long or branched or of long duration; the plugs upon the septa of fungal hyphae (Blackwell, 1949, fig. 5); the substance deposited upon the adjoining walls of gametophyte and sporophyte at the foot of certain mosses 'a deposit of peculiar structure' (Blaikley, 1933, p. 700, fig. 2), which Lorch (1925, pp. 120-126, figs. 1-5) interprets as a 'cellulose distinct from that of the cell-wall', and observes significantly that it attains its maximum development when the capsule has been differentiated. And here again in the infected tuber, is a similar deposit upon a haustorium through which has been passing an abundance of food. The theoretical conclusion is that this thickening is *effect* rather than *cause* of food transport. Is it possible that with further knowledge of the histology of the cell-wall, we may be able to cause at will the formation of a resistant type of cell-wall, which would mechanically resist fungal attack, by supplying to *the individual plant in the soil* the conditions required to bring about this desirable state? Years ago Cheeseman (1917) pointed out the difference in the thickness of the cell-wall of tubers immune and susceptible to blight: that the former had thicker cell-walls. He pointed out that when a variety is newly raised from seed the tuber had thick cell-walls and is then to a great extent resistant to the disease, but after a period of growth the cell-walls become thinner and the tuber more susceptible. He suggested that after this period, when the variety had become subject to the disease, a fillip might be given to the plant by a 'change of soil and climate'.

II. HAUSTORIA AND INTRACELLULAR HYPHAE IN OTHER SPECIES OF *PHYTOPHTHORA*

It is perhaps of interest to recall that there are very few records, and still fewer illustrations, of haustoria in other species of *Phytophthora*; and among these records, there is very rarely mention made of haustoria with the thickening which is so marked a feature of the haustorium developed in potato tubers. This latter observation is not surprising as the records published are usually of haustoria in the aerial shoot, leaf or axis, and *not* in tubers or such rhizomic organs. The former observation is not surprising either, as the study of *Phytophthora* spp. has often been carried out with cultures on agar.

Over sixty species of *Phytophthora* have been proposed, and on reading through the diagnoses of these, and the descriptions of the mycelium of each, we find that, in more than half of them, there is no mention whatever of haustoria or of intracellular hyphae. As for the remainder, we find in the descriptions of some ten species the statement that haustoria have been sought and not found.

Sixteen species are described as having haustoria, although the descriptions and figures are not always above criticism. These are listed below

and with each is supplied the authority, descriptive phrase used for the haustoria observed, and reference to figures, if any:

- P. fagi* [= *P. cactorum*] Hartig (1875, 1880), spherical. Figs. 4, 5 (1880).
P. phaseoli Thaxter (1889), rare, irregular.
P. nicotianae van Breda de Haan (1896). Fig. 12 is probably not of a haustorium.
P. colocasiae Raciborski (1900).
 Butler & Kulkarni (1913). Pl. II, fig. 2.
 Sawada (1919). Fig. 14.
P. syringae Klebahn (1905, 1909), branched. Abb. 25 (1909).
P. palmivora Butler (1907, 1910), branched, finger-shaped. Pl. IV, fig. 10 (1907). Text-figs. 1-4 and pl. V (1910).
P. arecae Coleman (1910), finger-like, sometimes dichotomous. Pl. XIV, figs. 1-3.
P. parasitica Dastur (1913), finger-shaped and button-shaped, rarely branched. Pl. III.
P. cambivora Petri (1917), globose and filamentous.
P. hydrophila Curzi (1927), 'sparsis et variis'.
P. boehmeriae Sawada (1927), cylindrical. Pl. I, fig. 16.
P. tabaci Sawada (1927), cylindrical. Fig. 20.
P. cyperi-rotundati Sawada (1927), ob-ovoid. Pl. II, Fig. 3 is probably not a haustorium.
P. cyperi-iriae Sawada (1931), ovoid.
P. canavaliae Hara (1930), cylindrical and globose. Fig. 362. 10.
P. paeoniae Cooper & Porter (1928), small, subspherical. Pl. XXIX, fig. A.

In Text-fig. 11 there are reproduced some of the published figures given in the above list, and herewith follow selected descriptions in greater detail.

Thaxter (1889) of *P. phaseoli* writes (p. 274): 'Mycelial hyphae branched, rarely penetrating the cells of the host by irregular haustoria.' Clinton (1906) cannot add to this. He says: 'The writer has not studied the special haustorial branches that push directly into the cells in search of food.'

Klebahn (1909) of *P. syringae*, also comments on their rarity and their small size and on their shape as being straight or curved or occasionally forked; he also notes the narrow entry tube of the haustorium: 'In die Zellen dringen hie und da Haustorien ein (Abb. 25). Zum Nachweis ist gebleichtes Material erforderlich. Der die Membran durchbohrende Faden ist dünn, der im Lumen der Zelle befindliche Teil ist gleichfalls fadenförmig, aber etwas dicker, ca. 1-2 μ dabei bis 20 μ lang und gerade oder etwas gebogen oder auch gabelig geteilt. Mitunter fand ich auch zwei Haustorien in dieselbe Zelle eindringen.'

Butler (1907) of *P. palmivora* says (p. 82): 'Branched finger-shaped haustoria enter the cells, which are rapidly killed and turned brown...' and he illustrates these in his pl. IV, where one drawing of a pair of haustoria at a bend in the hypha compares strikingly with Text-fig. 8 of the present paper. In a later paper Butler (1910, text-figs. 1-4, pl. V) further illustrates haustoria of *P. palmivora*.

A. *P. syringae* (a, b $\times$ 549, c $\times$ 1040), Klebahn, 1909. B. *P. arecae* ($\times$ 850), Coleman, 1910. 4, an intracellular hypha. C. *P. palmivora* ($\times$ 940), Butler, 1907. D. *P. palmivora*, Butler, 1910. E. *P. colocasiae* ($\times$ 930), Butler & Kulkarni, 1913. F. *P. colocasiae*, Sawada, 1919. G. *P. parasitica* ($\times$ 405), Dastur, 1913. A, an intracellular hypha. H. *P. paeoniae* ($\times$ 400), Cooper & Porter, 1928.



Text-fig. 111. Reproductions of some published figures of other species of *Phytophthora* illustrating haustoria and the intracellular hypha, and (in Fig. B, 4 and Fig. G, A) the intracellular hyphae. (Key opposite.)

Butler & Kulkarni (1913) of *P. colocasiae* write (p. 237): 'Haustoria are sent freely into the cells of the palisade, and stem parenchyma... simple, occasionally branched, finger-shaped... not differing from *P. palmivora* in essential.' His Pl. II, fig. 2, shows many slender haustoria, and part of this figure is reproduced in his text-book (Butler, 1918, p. 180).

Coleman (1910, p. 52) of *P. arcaeae* says: 'Haustoria are scarce, but are, however, to be found on careful search. They consist of finger-like processes which are at times dichotomously branched. Pl. XIV, figs. 1-3.' He proceeds to the valuable observation, a fact ignored by some later workers and responsible for their mistakes, that there are intracellular hyphae.

Dastur (1913, p. 181) writes: 'In *P. parasitica* both finger-shaped and button-shaped haustoria have been found. They branch very rarely. Whether these bodies which we call haustoria are true haustoria or the initial stage of branches of the intracellular mycelium remains an open question. The cellulose cap has been observed at the tips of these finger-like or button-shaped bodies which would leave no doubt as to their identity.'

Sawada claims to have observed haustoria in several species, but his figures vary very much. He evidently uses the term haustorium in a wide sense. His fig. 14 of *P. colocasiae* (1919), however, shows paired haustoria which are comparable with those Butler figured for *P. palmivora* and with those described in the present paper for *P. infestans* in the leaf mesophyll of potato.

There are other records either not so full or not so reliable as these quoted above, and some of them have confused intracellular hyphae with the so much slenderer haustoria.

Whereas Butler (1907, p. 82) of *P. palmivora*, says: 'Mycelium intercellular, only haustoria passing into the cells', Coleman (1910, p. 52) of *P. arcaeae*, says: 'a study of the course of the fungus in the interior of the nut shell reveals the fact that in the earlier stages, and even in the later stages in the deeper-lying tissue, the mycelium is practically confined to the intercellular spaces of the parenchyma... The fungus does not, however, confine itself to the intercellular spaces; later on, especially in the tissues of the shell lying near the surface, it is to be seen abundantly in the interior of the parenchyma and epidermal cells so much so that the lumina seem practically filled with mycelium (Pl. XII, fig. 5; Pl. XIV, fig. 4).' This latter figure is reproduced, along with one of his figures of haustoria, in Text-fig. 11 of the present paper. Dastur (1913) of *P. parasitica*, after giving the shape of haustoria on p. 181, describes, on p. 187, the shape of 'palmately branched hyphae'. So it would seem that intracellular, as well as intercellular, diverticula may or may not be formed according to conditions of parasitism or the nature of the species of host or strain of parasite. Some fifteen species have been described as having intracellular hyphae, and six of these as also having haustoria.

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MEASUREMENT OF MOULD GROWTH ON SOLID SUBSTRATES

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A new and rapid method is described for measuring the extent of mould growth on leather and other industrial products. By combining the method with total spore counts, values may be obtained for average size of spore in cultures of mixed species of mould.

INTRODUCTION

When comparisons of the value of fungicides are made in the laboratory, results of reasonably high accuracy may be obtained by simple measurements of the rate and extent of the inhibition of growth of single colonies of pure cultures on agar plates. The assessment of growth becomes more difficult when natural substrates such as leather, paper, or wood are used in the place of agar, and when single colonies of one species of mould are replaced by large numbers of colonies of mixed species, such as arise from natural infection or when the material is sprayed with a mixed culture. Various methods are in use for assessing the extent of mould growth on finished industrial products. Code numbers may be given to represent the amount of visible growth, the proportion of surface covered may be compared with a set of graded drawings in the manner of colour matching, or the time at which mould first becomes visible may be noted. Such methods are all highly subjective and may easily give erroneous results owing to differences of colour, variations in size of sporophore and type of mycelium.

To compare statistically the effect of mould growth on leather with certain of its physical properties, a method of growth assessment was required which would yield numerical values. Of the many possible ways of doing this (e.g. spore counts by haemocytometer, nephelometry of spore suspensions, light reflectance) the most rapid and simple appeared to be that of removing the mould spores completely from the leather, suspending them uniformly in liquid, and centrifuging them.

REMOVAL OF SPORES FROM LEATHER

A piece of 0.5 cm. bore glass tubing, about 20 cm. in length, was bent at right-angles to give a side arm of approximately 5 cm. The end of the side arm was fused and flattened, then ground with emery powder at right-angles to its length to produce a fish-tail jet with a narrow and even aperture. A quantity of powdered borax of less than 60-mesh particle size was introduced into the wide end of the inverted tube to give a depth of 1 cm., followed by a tight plug of cotton-wool. When the tube was placed upright and connected to a water vacuum pump, sufficient suction was produced to remove all surface spores from the grain surface of a

mouldy piece of leather when the lip of the tube was passed over it. Removal of spores from the flesh side was more difficult owing to the roughness of the surface, but measurements on the grain side of the leather only were found sufficient. When all visible growth had been sucked into the tube, the wool plug was removed and the contents washed with successive quantities of water into a small test-tube and shaken with lead shot to reduce clumping. In this way, mould spores from any desired area of leather could be evenly suspended in as little as 1 ml. of liquid. When examined under the microscope, the suspension appeared uniformly dispersed, gave good replications in haemocytometer counts, and contained no appreciable amount of mycelium or leather dust.

MEASUREMENT OF SUSPENDED SPORES

Centrifuge tubes suitable for measuring spore sediments were made by joining together a short 3 cm. diameter tube and a capillary to provide for a total volume of about 8 ml. and a capillary length of 5 cm. An internal capillary diameter of 0.07 cm. was used in the first trials, but this soon became obstructed and a wider tube of 0.1 cm. was finally adopted. In taking a measurement, a convenient quantity (generally 5 ml.) of spore suspension was pipetted into the centrifuge tube, which was then spun at 3000 r.p.m. for 5 min. No difference in the length of deposit resulted from longer runs, and in shorter periods the packing was not

Table 1. *Capillary volumes of measured spore suspensions*

Species	Vol. of suspension	Spores per ml. $\times 10^{-6}$ (by haemocytometer)	Capillary vol. of spores from 5 ml. suspension (μ l.)	Mean capillary volume (μ l.)
<i>Aspergillus niger</i>	5.0	15.0	6.25	6.09
	5.0	15.0	6.25	
	3.3	15.0	6.20	
	3.3	15.0	5.68	
<i>Penicillium wortmanni</i>	5.0	7.3	3.21	3.48
	5.0	7.3	3.58	
	3.3	7.3	3.43	
	3.3	7.3	3.70	
<i>Asp. + Pen. (1:1)</i>	5.0	11.2	4.96	4.73*
	5.0	11.2	4.50	

* Mean volume calculated from separate mean volumes = 4.78.

complete. The figures in Table 1 give a measure of the replication resulting from trials with standard pore suspensions of *Aspergillus niger* and *Penicillium wortmanni*, separately and together. When the two species were centrifuged together, a well-defined separation occurred in the centrifuge tubes, the smaller spores of *Penicillium* lying over the *Aspergillus* spores, but with the mixed cultures which grew on leather the variations in size and colour of spore were too great for any marked separation into genera. The length of the spore column was measured after centrifuging by means of a travelling microscope, and the corresponding volume read from a calibration curve prepared for each tube in turn by weighing different lengths of mercury to the top.

To clean the tubes, hypodermic needle tubing of suitable length attached to a syringe was inserted to the bottom of the capillary and the tube flushed repeatedly with water and finally rinsed with acetone.

To test the efficiency of the technique, single colonies of *Penicillium frequentans* were grown on agar. The agar was allowed to dry out and the spores were then removed by the micro-aspirator, suspended, and centrifuged: the results obtained are given in Table 2 and show that the centrifuge measurements give results of the same accuracy as spore counts by haemocytometer, but neither is closely related to the area of growth. Area measurements are not reliable indices of growth, even on homogeneous

Table 2. *Spore counts and capillary volumes of spores taken from measured colony areas (Penicillium frequentans)*

Colony area (cm. ²)	Total no. spores $\times 10^{-6}$ (by haema- cytometer)	Spores per unit area $\times 10^{-6}$	Capillary vol. of total spores (μ l.)	Capillary vol. per unit area (μ l.)
25.1	87.5	3.50	19.0	0.76
22.0	76.0	3.45	18.4	0.84
22.0	83.5	3.80	14.8	0.67
25.1	65.5	2.60	14.8	0.59
25.1	76.5	3.05	16.2	0.65
Standard deviation		0.42	—	0.087
Coeff. of variation		12.6	—	12.5

Table 3. *Spore diameters measured under microscope and calculated from capillary volumes*

Species	Spores in 5 ml. $\times 10^{-6}$ (by haema- cytometer)	Capillary vol. (μ l.)	Mean spore size (μ)	Calculated spore size (μ)	Error (%)
<i>A. niger</i> I	75	6.09	4.31	4.74	9.9
<i>A. niger</i> II	105	7.89	4.57	4.63	1.1
<i>P. spiculisporum</i>	1296	12.50	2.15	2.33	8.4
<i>P. wortmanni</i>	395	6.00	3.26	2.71	13.8
<i>A. flavus</i>	81	11.70	5.50	5.74	4.5

substrates such as agar, since zones of different amounts of growth are apparent even to the naked eye. The relationship between total spore count and volume of spores in the centrifuge tube is evidence that the method, while much easier to carry out than a count, is reasonably accurate. Moreover, by relating the centrifuge readings to the spore count in a mixed culture the approximate average spore size can be deduced, a factor indicative of the type of infection and hence of particular interest when assessments of fungicidal activity are being made.

If the spores in the centrifuge tube are closely packed so that each is touched by eight others (the closest form of regular packing of spheres), the space between the spores occupies 31.25% of the total volume (Pope, 1934). The measured volume V in the centrifuge tube will thus contain $68.75V/100\mu$ l. in solid spores. Hence, if the volume V of n spores in the centrifuge tube is in microlitres and the diameter of the spores is in microns, $d = 10 (1.315V/n)^{\frac{1}{3}}$.

The values of d given by this equation are compared with those found by microscopical measurement in Table 3.

The calculated values agree fairly well with the true values even when, as in the penicillia selected for measurement, the spores are not spherical. Since measurements of the mean size of the smallest spore are difficult to carry out accurately under the microscope and become more difficult when mixed cultures are examined, the method should prove particularly useful as an aid to the characterization of cultures growing on industrial products.

My thanks are due to the Council of the British Leather Manufacturers' Research Association for permission to publish this account of work carried out in their laboratories.

REFERENCE

- POPE, W. J. (1934). The stacking of spheres. *Chem. Ind.* **12**, 361-362.

(Accepted for publication 27 March 1952)

N O T E

CHAETOTHYRIUM BABINGTONII (BERK.) KEISSLER

Dr R. Santesson has kindly drawn our attention to the combination *Chaetothyrium babingtonii* (Berk.) Keissler, proposed in Rabenhorst's *Kryptogamen Flora*, **9** (1, pt. 2), 446, 1937, which antedates that proposed by us in *Trans. Brit. mycol. Soc.* **35**, 196, 1952. Keissler's name was published in a monograph of Pyrenolichens and was overlooked by us. It does not appear in the list of new fungus names published 1936-9, issued by the Commonwealth Mycological Institute. According to Keissler *Chaetasterina anomala* Bubák is another synonym of this much misunderstood species.

R. W. G. DENNIS and M. B. ELLIS

(Accepted for publication 23 January 1953)

PROCEEDINGS, 1952

MEETINGS

Meeting held at the London School of Hygiene and Tropical Medicine, London, W.C.1, at 11.0 a.m., 19 January 1952. The President, Mr A. A. Pearson, in the Chair.

- Miss M. WEBB. Preliminary studies on a species of *Typhula*.
 N. J. G. SMITH. Some curiosities among South African Gasteromycetes.
 J. F. SPILSBURY. Variation in culture of species of *Claviceps*.
 J. WEBSTER. Spore projection in *Nigrospora sphaerica*.
 S. D. GARRETT. Factors controlling rhizomorph initiation in *Armillaria mellea*.
 A. ANGUS. The taxonomy of *Ustilago hypodytes* (Schlecht.) Fr.

Meeting held at the London School of Hygiene and Tropical Medicine, London, W.C.1, at 11.0 a.m., 15 March 1952. The President, Mr A. A. Pearson, in the Chair.

- B. E. PLUNKETT. Pure culture experiments on sporophore production in *Collybia velutipes*.
 C. T. INGOLD. Freshwater aquatic Ascomycetes.
 C. L. DUDDINGTON. The predacious habit in Fungi.
 F. C. BUTLER. The saprophytic behaviour of two root disease fungi, *Helminthosporium sativum* and *Curvularia ramosa*.
 Miss K. SAMPSON. A *Physoderma* disease of Couch grass.
 G. C. AINSWORTH. The incidence of air-borne *Cladosporium* spores in London.

Meeting held at Birkbeck College, London, W.C.1, at 10.45 a.m., 17 October 1952. Dr S. D. Garrett in the Chair at the morning session; Prof. W. Brown in the Chair at the afternoon session.

THE PHYSIOLOGY OF THE HOST-PARASITE RELATIONSHIPS IN FUNGI AND BACTERIA

- Prof. W. BROWN. General Introduction.
 S. DICKINSON. The part played by thigmotropism in the physiology of obligate parasites.
 S. E. JACOBS and A. H. DADD. Factors affecting the infection of plants by *Corynebacterium fascians*.
 J. E. CROSSE. Factors affecting infection of cherry by *Pseudomonas mors-prunorum*.
 P. S. NUTMAN. Factors affecting the development of parasitic root nodules on clover.
 R. K. S. WOOD. Enzymological aspects of plant infection.
 F. T. LAST. The relationship between *Erysiphe graminis* and the growth of the host plant.
 Miss J. M. WRIGHT and P. W. BRIAN. Toxins in the etiology of diseases caused by *Alternaria solani*.
 I. A. S. GIBSON. Oxalic acid as an adjuvant to infection by *Aspergillus niger* in the Crown Rot disease of groundnuts.

Meeting held in the rooms of the Linnean Society, London, at 2.30 p.m., 6 December 1952. The President, Mr A. A. Pearson, in the Chair.

MICRO-STRUCTURE IN RELATION TO THE IDENTIFICATION OF HIGHER FUNGI

- E. J. H. CORNER. Hyphal analysis in Basidiomycetes.
 G. H. CUNNINGHAM. Hyphal systems as aids in identification of species and genera of the Polyporaceae.
 P. K. C. AUSTWICK. The application of hyphal analysis in *Leptoporus*.

ANNUAL GENERAL MEETING, 1952

The fifty-sixth Annual General Meeting was held in the rooms of the Linnean Society of London, at 12 noon on Saturday, 6 December 1952, with the President, Mr A. A. Pearson, in the Chair.

After the minutes of the previous Annual General Meeting had been read and signed Mr Pearson recorded with regret the deaths of Prof. F. T. Brooks, Dr W. R. Ivimey-Cook, the Rev. R. Barr and Mr G. C. Hughes. He then commented briefly on the year's activities.

The Treasurer, W. Buddin, presented his annual statement which was accepted *nem. con.*

The following officers and new Members of the Council for 1953 were then elected: *President*, C. T. Ingold; *Vice-Presidents*, C. J. Hickman and the two past-Presidents, P. H. Gregory and A. A. Pearson; *Secretary*, J. Webster; *Foray Secretary*, F. B. Hora; *Treasurer*, W. Buddin; *Editors*, P. H. Gregory and G. C. Ainsworth; *Members of Council*, C. C. V. Batts, P. W. Brian, C. L. Duddington, J. T. Palmer and G. Smith (to replace J. Brooke, F. B. Hora, Miss F. Joan Moore, N. F. Robertson and J. Webster). J. E. Crosse, C. J. Hickman, J. E. E. Jenkins, N. F. Robertson and Miss G. M. Waterhouse were elected as new members of the Plant Pathology Committee (to replace J. Colhoun, W. J. Dowson, S. D. Garrett, Miss L. E. Hawker and S. J. Hughes). Fourteen members and one associate were elected making a total of forty-six new members and five new associates for the year.

The following resolution was adopted: 'that Council recommends an increase in the Associate membership subscription from 5s. to 10s., as from 1 January 1953'.

Following a brief discussion of the 1953 programme the meeting concluded with a vote of thanks to the President for his services to the Society.

C. J. HICKMAN,
Secretary

	£	s.	d.	£	s.	d.	£	s.	d.
1 July 1951, Balance brought forward	...	...	...	1210	14	4			
Cambridge University Press:									
Cost of production of <i>Transactions</i> :									
Vol. xxxiv (1100 copies) and reprints ...	578	15	0						2443 10 11
Purchase of <i>Transactions</i> , reprints, etc. ...	131	7	4						19 19 0
Grants on Cheesman and Pethybridge Funds	59	15	0						14 10 0
Subscriptions:				769	17	4			
Woolhope Club ...									1 0 0
Council for Promotion of Field Studies ...	2	18	6						2 2 0
British Co-ordinating Committee for Nature	3	2	0						
Conservation ...	84	0	3						2 0 0
Postages, Stationery, etc. ...	21	14	0						
Printing:				111	14	9			5 2 0
Sundry ...	2	0	0						60 7 3
Guide to Literature ...	563	5	11						59 7 11
50-Year Index and Honorarium ...	8	7	0						36 0 0
Library purchases ...	11	5	0						424 10 0
Fees for Meetings ...	97	9	6	682	7	5			519 17 11
Balance:				493	2	3			2 14 3
At Midland Bank ...									3 8 0
In Post Office Savings Bank ...									493 8 1
1951 Grant from Royal Society towards									217 17 5
Vol. xxxiv and 50-Year Index ...	229	0	0						711 5 6
Interest:									
Capital Reserve Fund ...	40	7	6						
Post Office Savings Bank ...	21	14	5						
				62	1	11			
				£3780	14	10			£3780 14 10

CAPITAL RESERVE FUND ACCOUNT (incorporating the Cheesman, Lister, Pethybridge and Printing Funds)

Nominal values of Stock	3½% War Stock £625
	3% Defence Bonds £200
	Savings Certificates £675
	Total £1500

Examined and found correct, W. C. MOORE

(Signed) WALTER BUDDIN, Hon. Treasurer.

Donations from numerous members to the several Funds of the Society are gratefully acknowledged.

THE PERRANPORTH FORAY

23-25 May 1952

By G. SMITH, *Foray Secretary*

The twenty-third Spring Foray was held at Perranporth, north Cornwall, from Friday, 23 May, to Sunday, 25 May 1952. Headquarters was at the Droskyn Castle Hotel, where the management did all in their power to make the accommodation suitable for the peculiar needs of the 'forayers'.

Friday was spent exploring Gear Sands, part of the extensive dunes which lie adjacent to the village. There was said to be a stream down the middle of the area, but this was almost completely dried up, with only a few marshy patches to indicate its whereabouts. A few members made profitable collections, whilst those who found little did at least enjoy a day in bright sunshine. The most interesting find was *Chitonospora ammonophilae* Bomm. Rouss. & Sacc., this being the second British record of the species. After lunch some members explored the dunes further, whilst others visited a nearby hollow with a stream and some copse.

The following day the first visit was to the garden of the late Mr F. Rilstone, Lambourne Hill, Penhallow, where our host had a number of interesting fungi to exhibit, including a second British record in *Eutypella acericola* (Sacc.) Berl. Mr Rilstone had also arranged for the party to visit Mr Congdon's garden at Three Burrows, to see, in particular, *Chaetothyrium babingtonii* (Berk.) Keissler, on *Eleagnus*. The route back to Perranporth was by St Agnes Beacon, where unfortunately, most of the gorse had been burnt, and this too recently to provide any mycological interest.

The ground explored on Sunday included Perranzabuloe Churchyard and Perran Church Wood, where a fair number of rusts were collected but only a small number of other fungi.

Most of the ground in the area was very dry and there was comparatively little woodland, so that it is not surprising that the list of the larger fungi is shorter than usual.

In addition to the organized forays, collecting was done by some members in various other localities during the week-end—the local wolfram mines, Perranporth village, and Pentire Head near Newquay.

List of species

C. = Perranzabuloe Churchyard; D. = Dunes (Gear Sands); L. = Lambourne Hill, Penhallow; M. = Wolfram mine; P. = Perranporth; Ph. = Pentire Head; T. = Three Burrows; W. = Perran Church Wood.

Names without author citations for Agaricales are taken from Pearson & Dennis, *Trans. Brit. mycol. Soc.* 31, 145-190, 1948, those for other Hymenomycetes from Rea, *British Basidiomycetae*, 1922.

PHYCOMYCETES

Bremia lactucae Regel, on *Sonchus oleraceus*, P.

Peronospora aparines (de Bary) Gäum., on *Galium aparine*, T., conglomerata Fuckel, on *Geranium pusillum*, D., destructor (Berk.) Casp., on *Allium triquetrum*, T., myosotidis

Fuckel, on *Myosotis hispida*, D., valerianellae Fuckel, on *Valerianella locusta*, D.,
viciae (Berk.) Casp., on *Vicia sativa*, L.
Pseudoperonospora humuli (Miyabe & Tak.) Wilson, on *Humulus lupulus*, D.

ASCOMYCETES

PYRENOMYCETES

Acrospermum compressum Tode ex Fr., on *Oenanthe crocata*, L.
Anthostomella appendiculosa (Berk. & Br.) Sacc., on *Rubus*, P., tomicoides Sacc., on
Rubus, L.
Calonectria ochraceopallida (Berk. & Br.) Sacc., on *Ulex europaeus*, P.
Clypeosphaeria notarisii Fuckel, on *Rubus*, D.
Chaetothyrum baringtonii (Berk.) Keissler, on *Eleagnus*, T.
Chitonospora ammophilae Bomm., Rouss. & Sacc., on *Ammophila*, D.
Diaporthopsis pantherina (Berk.) Wehmeyer, on *Pteridium*, L.
Diatrype stigma (Hoffm. ex Fr.) Fr., on *Hedera helix*, P.
Didymosphaeria diplospora (Cooke) Rehm., on *Leycesteria* and *Rubus*, L., palustris
(Berk. & Br.) Sacc., on *Carex riparia*, D.
Dothidella trifolii Bayliss Elliott & Stansfield, P.
Eutyphella aericola (Sacc.) Berl., on *Acer pseudoplatanus* and *Fraxinus excelsior*, L.
Gloniopsis levantica Rehm, on *Rubus*, D., L., on *Ulex europaeus*, P.
Hypoxyton multifforme (Fr.) Fr., W., rubiginosum (Pers. ex Fr.) Fr., D., serpens (Pers.
ex Fr.) Fr., W.
Leptosphaeria acuta (Hoffm. ex Fr.) Karst., on *Urtica dioica*, D., agnita (Desm.) Ces.
& de Not., on *Eupatorium cannabinum*, P., clivensis (Berk. & Br.) Sacc., on *Senecio
jacobaea*, D.
Lophiostoma arundinis (Fr.) Ces. & de Not., on *Phragmites communis*, P., viridarium
Cooke, on *Rubus*, L.
Lophodermium arundinaceum (Schrader ex Fr.) Chev., on *Ammophila*, D.
Melanopsamella inaequalis (Grove) v. Höhnelt, on *Ulex europaeus*, P.
Peroneutypa heteracantha (Sacc.) Berl., L.
Phyllachora graminis (Pers. ex Fr.) Fuckel, on *Dactylis glomerata*, P.
Pleospora herbarum (Pers. ex Fr.) Rabenh., on *Rubia peregrina*, P.
Rhopographus filicinus (Fr.) Fuckel, on *Pteridium aquilinum*, P.
Rosellinia aquila (Fr.) de Not., on *Fraxinus excelsior*, L.
Stigmatea robertiana (Fr.) Fr., on *Geranium robertianum*, P.

DISCOMYCETES

Dasyscypha nidulus (Schm. & Kunze) Mass. on *Oenanthe crocata*, L., virinea (Batsch
ex Fr.) Fuckel, on *Ulex europaeus*, L.
Sclerotinia sphaerosperma Gregory, on *Allium triquetrum*, L.

BASIDIOMYCETES

UREDINALES

Coleosporium sonchi-arvensis (Pers.) Lév., on *Sonchus oleraceus*, P.
Milesina scolopendrii (Fuckel) Jaap, on *Phyllitis scolopendrium*, T.
Phragmidium sanguisorbae (DC.) Schroet., on *Poterium sanguisorba*, D. violaceum
(Schultz) Wint., on *Rubus*, C.
Puccinia antirrhini Diet. & Holw., on cultivated *Antirrhinum*, P., betonicae DC., on
Stachys officinalis, C., cnici H. Mart., on *Cirsium eriophorum*, C., hydrocotyles (Mont.)
Cooke, P., hypochoeridis Oud., on *Hypochaeris radicata*, C., iridis Rabenh., on *Iris
foetidissima*, D., malvacearum Mont., on *Malva sylvestris*, P., phragmitis (Schum.)
Körn., on *Phragmites communis*, P., symnii Biv.-Bernh., P., sonchi Rob., on *Sonchus
oleraceus*, P., taraxaci Plowr., on *Taraxacum officinale*, C., P., umbilici Guep., on
Umbilicus rupestris, W., vincae Berk., on *Vinca major*, P., violae DC., on *Viola rivi-
niana*, D.
Pucciniastrum epilobii Oth., on *Epilobium hirsutum*, D.
Triphragmium ulmariae Wint., on *Filipendula ulmaria*, D.

Uredo ammophilina Kleb., *D.*

Uromyces acetosae Schroet., on *Rumex acetosa*, *P.*, *ambiguus* (DC.) Lév., on *Allium ampeloprasum*, *D.*, *fabae* (Pers.) de Bary, on *Vicia cracca*, *L.*, *jaapianus* Kleb., on *Trifolium dubium*, *P.*, *poae* Rabenh., on *Ranunculus ficaria*, *L.*, on *Poa pratensis*, *W.*, *rumicis* (Schum.) Wint., on *Rumex crispus*, *P.*, *scillarum* (Grev.) Wint., on *Scilla verna*, *Ph.*

USTILAGINALES

Farysia olivacea (DC.) Syd., on *Carex riparia*, *D.*

Urocystis violae (Sow.) Fisch. v. Waldh., on *Viola riviniana*, *P.*

HYMENOMYCETES

Auricularia auricula-judae, *D.*

Clitocybe aurantiaca var. *nigripes*, *M.*

Coprinus sterquilinus, *D.*

Fomes annosus, *M.*

Peniophora cinerea, *L.*

Pholiota praecox, *D.*

Polyporus squamosus, *C.*, *D.*, *stipticus*, *M.*

Psathyrella prona, *D.*

Psilocybe ammophila, *D.*, *foenisecii*, *D.*

Stereum hirsutum, *M.*

Trametes rubescens, *C.*, *D.*

FUNGI IMPERFECTI

COELOMYCETES

Camarographium stephensii (Berk. & Br.) Bubák, on *Pteridium*, *L.*

Dinemasporium graminum Lév. var. *strigulosum* Karst., on *Juncus effusus*, *L.*

Neottiospora caricum Desm., on *Carex riparia*, *D.*

Septoria rubi Westend., on *Rubus*, *D.*

Thyriostroma spiraeae (Fr.) Died., on *Filipendula ulmaria*, *P.*

Tiarospora perforans (Rob.) v. Höhnelt, on *Ammophila arenaria*, *D.*

HYPHOMYCETES

Acrothecium simplex Berk. & Br., on *Urtica dioica*, *P.*

Alternaria tenuis Auct., on *Eupatorium cannabinum*, *P.*

Botrytis cinerea Pers. ex Fr., on *Eupatoria cannabinum*, *P.*

Cercospora myrti Erikss., on *Myrtus communis*, *L.*

Cladosporium herbarum (Pers.) Link ex. Fr. on *Juncus effusus*, *P.*

Cylindrotrichum oligospermum (Corda) Bon., on *Dipsacus*, *D.*

Dematium hispidulum Fr., on *Carex riparia*, *D.*

Dendryphiella interseminata (Berk. & Rav.) Bubák & Ranojevič, on *Heracleum sphondylium* and *Oenanthe crocata*, *L.*

Dendryphion comosum Wallr., on *Acer pseudoplatanus* and *Filipendula ulmaria*, *L.*, *Hedera helix*, *P.*, *Humulus lupulus*, *L.*, *Lonicera nitida*, *T.*, *Urtica dioica*, *D.*, *L.*, *laxum* Berk. & Br., on *Cirsium*, *D.*

Haplaria grisea Link ex Chev., on *Ulex europaeus*, *P.*

Helminthosporium microsorum Sacc., on *Quercus ilex*, *C.*, *simplex* Kunze ex Fr., on *Fraxinus*, *D.*, *smithii* Berk. & Br., on *Ilex aquifolium*, *L.*, *velutinum* Link ex Fr., on *Acer pseudoplatanus*, *L.*

Oidium quercinum Thüm., on *Quercus robur* wood, *W.*

Ovularia decipiens Sacc., on *Ranunculus parviflorus*, *D.*, *obliqua* (Cooke) Oudem., on *Rumex crispus*, *P.*

Papularia arundinis (Corda) Fr., on *Arundinaria*, *P.*, *T.*, *sphaerosperma* (Pers. ex Fr.) v. Höhnelt, on *Arundinaria*, *P.*

Periconia atra Corda, on *Juncus effusus*, *P.*, *byssoides* Pers. ex Schw., on *Acer pseudoplatanus*, *Angelica sylvestris*, *Cirsium palustre*, *Heracleum sphondylium* and *Humulus lupulus*, *L.*, *chlorocephala* Fres., on *Paeonia*, *L.*, *minutissima* Corda, on *Arrhenatherum elatius* var. *tuberosus*, *P.*, *Carex riparia*, *D.*, *Melandrium rubrum*, *Phragmites communis* and *Pteridium aquilinum*, *L.*

- Phaeoisaria cornui (Bainier) Mason, on *Sambucus nigra*, L.
 Ramularia geranii (Westend.) Fuckel, on *Geranium dissectum*, L., *W.*; heraclei (Oudem.)
 Sacc., *T.*, lampsanae (Desm.) Sacc., *P.*, primulae Thüm., on *Primula veris*, D.,
 urticae Ces., *D.*
 Sarcopodium circinatum Ehrenb., on *Urtica dioica*, D.
 Speira toruloides Corda, on *Cortaderia selloana*, *P.*
 Sporidesmium fusiforme Nees ex Fr., on *Sambucus nigra*, L.
 Sporocybe cuneifera (Berk. & Br.) Sacc., on *Sambucus nigra*, L., flexuosa (Masse) Mason,
 on *Betula*, *W.*
 Stachybotrys atra Corda, on *Ulex europaeus*, *P.*, dichroa Grove, on *Dipsacus* and *Iris*, *D.*,
Kentranthus ruber, *P.*, *Oenanthe crocata*, L.
 Tetraploa aristata Berk. & Br., on *Cortaderia selloana*, *P.*
 Torula herbarum Link ex Fr., on *Acer pseudoplatanus*, *Cirsium palustre* and *Oenanthe crocata*,
L., *Urtica dioica*, *D.*, *L.*
 Triposporium elegans Corda, on *Rubus*, L.
 Verticillium cyclosporium (Grove) Hughes, on *Ulex europaeus*, *P.*
 Volutella arundinis (Desm. ex Fr.) Sacc, on *Juncus effusus*, *P.*

MYCETOZOA

- Ceratiomyxa fructiculosa Macbr., *W.*
 Lycogala epidendrum Fr., *W.*

THE FRENCH FORAY

13-21 September 1952

By F. B. HORA

The forty-eighth Annual Foray took the form of a Joint Meeting with the French Mycological Society and was centred on Mamers, a small town of less than 5000 inhabitants situated about 100 miles south-west of Paris and some 25 miles almost due north of Le Mans. Approximately 140 people (45 from the British Isles) attended, and this large number necessitated about 30 being lodged at Bellême, an even smaller town 10 miles to the east of Mamers.

The Foray was formally opened on the morning of 4 September (Sunday) in the Salle des Fêtes which had been generously put at our disposal by the Mamers Municipality for the whole week. Mr Maublanc, General Secretary of the French Society, took the chair and to the evident pleasure of all, he proposed that our own President should be *Président de la Session*. Mr Pearson accepted this task and took the Chair at all meetings during the Foray. As is customary on these occasions a *Président d'honneur* is elected and this was Mr M. A. Donk the eminent Dutch mycologist. We were all very pleased to note that both Mr and Mrs Donk have almost recovered their normal health after a long period of internment in a Japanese prisoner-of-war camp in Indonesia. The meeting adjourned shortly after midday to attend a *Vin d'honneur* at the Town Hall where we were officially welcomed on behalf of the inhabitants of Mamers by the Mayor in a very friendly speech accompanied by a popping salute from numerous champagne bottles. It fell to Mr Pearson to reply to this address of welcome and this he did without a single note in a superb speech.

Serious collecting began the same afternoon. In arranging the programme our French colleagues had closely followed our own practice of alternating a whole day's collecting with a half-day's, so as to allow time for working over material. The three half-days were to local areas, the first foray of all being at the Bois de Clinchamps; on Tuesday afternoon to Igé (the estate of the Comte d'Orglandes) and on Saturday afternoon to the Bois des Chaises (estate of Mlle. Thoreau). The three full days were to State forests: on Monday to the Forêt de Jupille, south-east of Le Mans; on Wednesday to the Forêt d'Écouves, due north of Alençon, and on Friday to the Forêt de Bellême. On this Friday we also attended a *Vin d'honneur* given by the Mayor of Bellême. Thursday was a 'free day', but at an evening Meeting an interesting communication was read by Mr Maublanc to the effect that *Inocybe pudica* Kühner is the same as *I. geophylla* var. *lateritia* (Wein.) Stev.; a possibility already suggested by Dr R. W. G. Dennis (*Trans. Brit. mycol. Soc.* 35, 118, 1952). Following a most erudite paper by Mr Romagnesi on the nomenclature of a species of *Psathyrella* (Romagnesi prefers the generic name *Drosophila* Quél.), Mr Pearson delivered his presidential address as President of the British Mycological Society. A vote of thanks proposed by Madame Le Gal was warmly seconded by myself.

An important event took place on Tuesday, 16 September, when we were honoured by a visit from the President of the French Mycological Society, Mr Dujarric de la Rivière of the Pasteur Institute, well-known for his work on the toxicology of fungi.

It is the custom of the French Mycological Society to hold a banquet at the termination of the week's work and this took place on Saturday evening at the Hôtel du Bon Laboureur. More than 100 people attended and it was a great success. As first toast our President proposed: 'Notre jeune reine Elizabeth'.

There can be no doubt that the Joint Foray fulfilled our best expectations. Contacts were renewed and many new ones made; much useful information was exchanged and the discussions on critical species were of great help. Some of us saw more toadstools in that week than we have seen recently in a whole season. All of us saw a larger or smaller number of species that were entirely new to us. And the weather had been kind: there was rain a week or so before we arrived, but not once were we inconvenienced by it.

It is now my pleasure to place on record our thanks to those who did so much for the success of the Joint Foray. We are especially indebted to our Secretary Dr C. J. Hickman and to Mr A. Maublanc and Mr Y. André of the French Mycological Society who carried out the preliminary negotiations. Our very grateful thanks are due to the local organizers Mr Ligo (Mamers) and Mr Leclair (Bellême) who had the difficult task of accommodating us in their home-towns and solving our day-to-day problems. We are also very sensible of the honours accorded us by the Mayors of Mamers and Bellême. The *Vin d'honneur* in each case was much enjoyed. I would like also to pay a tribute to Madame and Monsieur Gébert of the Hôtel du Bon Laboureur who provided the final banquet. It conformed to the best French traditions of excellence. A special word of thanks—and praise—must also be accorded to those eminent mycologists of all nations who so freely gave us the benefit of their learning and experience. Finally we are greatly indebted to the Comte de Levis-Mirepoix, the Comte d'Orglandes and Mlle Thoreau who allowed our large party to wander freely over their beautiful estates and who so generously provided us with refreshments when our collecting was over. In a similar connexion must also be mentioned the officers of the French State Forests who conducted us over their magnificent forests which they love and tend so well.

In reporting on the fungus flora, I have avoided simple lists, and what follows represents an account of the more interesting finds. It will be evident that it is weighted in favour of the larger Basidiomycetes of which about 350 species were collected. Our picture of the smaller Basidiomycetes, Ascomycetes and micro-fungi in general is much less complete. There was only the occasional collector in these groups and their efforts were handicapped by the lack of microscopes. (The full list will appear in the *Bulletin de la Société Mycologique de France*.)

What I have done for the larger Basidiomycetes is to go systematically through Pearson & Dennis's 'List of British Agarics and Boleti' (*Trans. Brit. mycol. Soc.* **31**, 145-190, 1948), picking out finds which I believe will

be of general interest. Nomenclature follows that list (without author citation) or Konrad and Maublanc (*Les Agaricales*, Paris, Lechevalier, Vol. I, 1948, Vol. II, 1952). An asterisk (*) indicates that no reliable record is known for Britain.

In *Amanita*, undoubtedly the most outstanding find was **A. ovoidea* (Fr. ex Bull.) Quél. This is very similar to a large and very stout *A. virosa* and one would have to have considerable confidence in its correct determination before making a meal of it, for all our French colleagues agreed that it is an excellent edible toadstool. Like the related **A. caesarea* (Fr. ex Scop.) Quél., it is not found in this country, being a more southern European species and not getting farther north than Paris.

In *Tricholoma*, Romagnesi identified one of his as yet unpublished species. There was also a fine specimen of *T. colossus*. *Clitocybe tabescens* was represented by the largest groups (and individuals) I have ever seen, and I was able to satisfy myself by getting up in the middle of the night that the poisonous *C. olearia* is luminous. On cones of *Pinus maritima*, numerous specimens of *Mycena seynii* were gathered and the most perfect examples of *Collybia racemosa* were collected from two widely separated localities. I was particularly pleased to see a group of *Lentinus cochleatus* without the sweet, persisting, aromatic smell. There are other slight differences from the much more common sweet-smelling form, and recently Konrad and Maublanc have separated the non-smelling form as *Lentinellus inolens* Konrad & Maublanc. The closely related **Lentinus bisus* Quél. *sensu* Bres. was found once. It is sometimes regarded as a form of the very variable *L. omphalodes*. Fine specimens of *Hygrophorus nemoreus* were seen as well as *H. cossus*. The interest of the latter common species is that the French mycologists do not regard *H. eburneus* as more than a variety of it. *Lactarius* was well represented. Perfect examples of **L. salmoneus* Heim & Leclair (*Revue de Mycologie*, 15, 65, 1950) and of **L. semisanguinius* Heim & Leclair were found, each twice, and in different localities. The normal deliberations of agaricologists in the field over their finds is rarely carried out more than *sotto voce*: one might almost talk of a murmuration of mycologists. All such suggestions of quietude were forgotten when the first specimens of *L. salmoneus* were brought to Mr Leclair. It is not unlikely that both these species occur in this country. Mr Romagnesi identified *L. ichoratus*, and other interesting finds were *L. trivialis* and *L. hyginus*. It was instructive to see numerous examples of *L. decipiens* Quél. and its variety *lacunarum* Romagnesi. We, in this country, have tended to overlook these fungi, but thanks to Mr Pearson's Monograph (The genus *Lactarius*, *Naturalist*, Lond., pp. 81-99, 1950) they are both now pretty well known. In my view, there is a lot to be said for following Lange who raised the variety to the status of a species: *L. lacunarum* (Romagn.) Lange. Fine examples of *L. uvidus* were seen. The milk takes about 5-10 minutes to turn a violet colour, and a very interesting observation on this colour change was made by Mr Rouget, a Belgian bacteriologist. He noticed that if the milk was drawn across the gills of a *Russula* species, the colour change took place in a matter of under 5 minutes, usually 2-3 minutes. I was able to confirm this myself with at least three different species of *Russula*. But there was one *Lactarius*

which defied all attempts at identification: a fine large specimen, straw coloured like *L. scrobiculatus*, but unlike that species in having white, unchangeable, mild milk. We must not leave this genus without passing on to a most useful field device in connexion with species such as *L. hepaticus* (*theiogalus* sensu Rea) whose milk turns yellow only tardily. In this country we have been accustomed to speed up the colour change somewhat by transferring a drop of milk to the finger. We were shown time and again that by transferring to a handkerchief, the change was even quicker and more pronounced.

The genus *Russula* gave almost as much excitement as *Lactarius*. Mr Leclair's own **R. aquosa* was re-found; it is a species near *R. atropurpurea*. Mr Romagnesi, who has paid particular attention to this genus, showed me *R. delicata* and **R. delicula* Romagn. The latter is easily confused with the var. *glaucophylla* Quél. of the former, but has much wider spaced gills: when seen thus, side by side, there can be no doubt about their separateness. There is no clear evidence that *R. delicula* occurs in this country. Mr Romagnesi also showed us what he considers to be *R. cutifracta* Cooke, a much disputed species, commonly regarded as a very close ally of *R. cyanoxantha*. It was also extremely valuable to have his determination of those two very closely related species, *R. amoena* and *R. violeipes* Quél. *R. clariana* R. Heim, named in honour of Mr Leclair and very closely related to *R. violacea*, was seen, as also was *R. melitodes* Romagnesi, recently described from the Paris area. Finally, a puzzling species found by Mr John Brooke was tentatively named *R. melzeri*, a species in the group centring on *R. velenovskyi* and not yet fully defined.

Mr Romagnesi has also made a special study of the pink wavy-spored genera *Entoloma*, *Leptonia*, *Nolanea*, *Eccilia* and *Claudopus*, all of which genera he prefers to treat under the single generic name *Rhodophyllus* Quél. He re-found his **Entoloma pseudo-eccentricum*, a species allied to *E. rhodopolium*, and also identified a very pretty *Pluteus*, **P. nigrofloccosus* (Roman Schulzer) Favre, formerly grouped under *P. cervinus* var. *atromarginatus*.

Amongst brown-spored species, *Pholiota caperata* was found in quantity. The genus *Cortinarius* aroused lively interest and we were fortunate in having Mr Piane to help us with identifications. **C. (Phleg.) balteatocumatilis* Henry and **C. (Phleg.) subtortus* Fr. ex Pers. were perhaps the more interesting species. The latter has large cystidia which is unusual in this genus. No outstanding species of *Inocybe* were listed but this may be due to the scarcity of microscopes without which only a very few species can be named and even most of these not with full confidence.

Few purple-spored species were found. It was pleasant to see the true *Hypholoma lacrymabundum* of Fries. Unfortunately the specific epithet is ambiguous and many mycologists prefer the binomial *H. cotoneum* (Quél.) Lange. Only one species of *Psalliota* was found, *P. arvensis*.

Of the black-spored species a fine tuft of **Coprinus erythrocephalus* Lévillé was collected. It is a beautiful small tufted toadstool with its orange-red cap—an unusual colour for a *Coprinus*. It probably occurs in Britain but there is no authentic record. It is not unlikely that *C. roseotinctus* Rea is the same thing.

There is little to report for the genus *Boletus*, but it was a most instructive occasion to see at one and the same time *B. edulis*, *B. pinicola* and *B. aereus*.

The following account of the polypores (Aphyllorphorales) is based entirely on information kindly supplied by Mr Peter Austwick. Some thirty species were collected belonging to the Friesian genera *Polyporus*, *Polystictus* and *Poria*. All but two of the species are known from this country. These are **Polyporus forquignoni* Quél. and **P. pes-caprae* Fr. ex Pers. Of particular interest is *P. albellus* Peck which proved to be the commonest white polypore to be collected in contrast to its rarity in Britain. It was found predominantly on hardwood and varied in colour from pure white to dark grey, always showing the characteristic suede-like surface and soft watery flesh.

Of the remaining larger Basidiomycetes, I think I need only mention **Stereum insignitum* Quél. It is not on record for this country as yet and I recall the pleasure with which Miss Wakefield pointed it out to me.

A collection of rusts was made by Dr Manners and these proved to be species common to both sides of the Channel.

I am indebted to Mr W. D. Graddon for the following account of Discomycetes. Nomenclature usually follows Ramsbottom & Balfour-Browne's List (*Trans. Brit. mycol. Soc.* **34**, 38-137, 1951). The outstanding impression was of the prevalence of Operculate species; the opportunity to study fresh material of these, more rarely seen at home, doubtless resulted in some neglect of the Inoperculates. Some seventy species were collected but space allows mention of only a few. Among the larger operculates, excellent gatherings were seen of *Otidea onotica*, *O. alutacea* and of the closely related *Pseudotis apophysata*. *Helvella crispa* and *H. lacunosa* occurred as fine large plants in several localities and collections were made of a small neat *Helvella*, possibly *H. sulcata*. The smaller species with excitingly sculptured spores included *Peziza bicucullata* Boud., *Ciliaria pseudotrechispora* (Schroet.) Boud. and *Ascobolus atro-fuscus*. Species with spherical spores were represented by a good collection of *Pulvinula constellatio*. Several Aleurias and Galactinias were found and the sight of *G. saniosa* producing milk which quickly turned really blue for Mme Le Gal when she broke the fungus, is a happy memory.

Among the inoperculates, acorns everywhere carried fine growths of *Stromatinia pseudotuberosa*, and *Phialea echinophila* was on old chestnut involucre. Perhaps the most spectacular gathering was an oak branch some 2 ft. long, densely covered with the fine green apothecia of *Chlorosplenium aeruginascens* (Nyl.) Karst. *Dasyscypha sulphurea* (Pers ex Fr.) Mass. was found in plenty and in lovely condition on *Urtica* stems and *D. brevipila* (one of Mme. Le Gal's own species) was taken frequently on a variety of woody hosts. Opportunity was taken to search out *Pyrenopeziza ebuli* (Fr.) Sacc., on *Sambucus ebulus*—a rare plant at home but frequent around Mamers and Bellême. Finally, a beautiful and abundant collection of *Coccomyces coronatus* on oak leaves deserves mention.

A most intensive search was made by Dr Lilian Hawker for hypogeous Ascomycetes and a large amount of material was obtained. This has now been worked over by Dr Hawker, and I am grateful to her for the following

notes. Almost the whole of the collection turned out to belong to the genus *Elaphomyces*, and with one exception nearly the whole of it was referable to the common and widespread species *E. granulatus* Fr. (= *E. cervinus* (Pers.) Schröter). The exception was a small white species tentatively determined as *E. mutabilis* Vitt. var. *flocciger* Tul. The absence of true truffles, species of the genus *Tuber*, was not unexpected. It soon became evident from examination of the ground flora that the underlying soil was distinctly acid: true truffles are essentially characteristic of a more or less calcareous soil. It is interesting to note that in De Ferry de la Bellone's account (La Truffe, Paris, 1888), neither *Tuber aestivum* Vitt. nor *T. melanospermum* Vitt. are recorded from the district. Miss G. M. Waterhouse reports the hyperparasite *Cicinnobolus cesatii* de Bary on the *Oidium* state of *Sphaerotheca euphorbiae* (Cast.) Salm. on *Euphorbia peplus*.

Of other Ascomycetes, perhaps the one which caused the most interest was the perfect stage of *Microsphaera alphitoides* Grif. & Maubl. (= *M. quercina* (Schw.) Cke. & Peck).

It only remains for me to express my personal thanks to those who have helped me in the preparation of this report. In addition to those already named, I should like to mention Mr Peter Orton and Miss Margaret Holden who acted as recorders for the larger Basidiomycetes.

LONDON AND PROVINCIAL LOCAL FORAYS, 1952

By G. SMITH

Four one-day forays were held in the London area: Whippendell Woods, near Watford on Sunday, 28 September; Ruislip Woods, Saturday, 4 October; Virginia Water, Saturday, 11 October; and Prince's Coverts, Oxshott, Saturday, 18 October. All the forays were well attended and, whilst there was nowhere a glut of fungi, some good collections were made.

Two forays were held in the Sheffield area: Eccleshall Woods and Limb Valley, Saturday, 11 October; and Longshaw Pastures and Sheffield Plantation, Sunday, 12 October. On the latter date there was also a foray for Birmingham members, to Lickey Hills. Two forays were held in conjunction with the North Western Naturalists' Union: to Delamere Forest, Saturday, 18 October; and Formby and Freshfield, Sunday, 16 November.

THE TWENTY-SIXTH ANNUAL PLANT
PATHOLOGY FIELD DAY
4 JULY 1952

The Twenty-sixth Annual Field Day was held at The Hawthorndale Laboratories, Bracknell, of Imperial Chemical Industries Ltd.

A party of about 70 members assembled at 10.30 a.m. and were welcomed by Mr R. V. Tipler who indicated that Dr Tanner, the head of the Laboratories, was unavoidably absent.

Members were conducted round the Mycological Section of the Laboratories and the Estate. Those who wished were able to visit the Entomological Section also. Miss M. E. Kennedy demonstrated methods of culture maintenance by freeze drying and also sporulation of *Alternaria solani*. Mr J. L. Charlton illustrated *in vitro* bio-assay methods for fungicides and bactericides and showed morphogenic effects of chemicals on fungi. Aspects of industrial microbiological problems such as timber sap stain and decay, moulding of rubber and textiles, prevention of leather cloth deterioration, and paper mill and pulp problems were discussed by Mr J. N. Turner and Miss S. E. Parkinson. The work on bio-assay of soil fungicides was explained by Mr C. E. D. Smith. The evolution of seed fungicides, the concern of Mr I. W. McC. Callan, was demonstrated in the laboratory and glasshouses. Field plot trials with cereal seed dressings and seed dressing machinery and experimental threshing equipment were also seen. Dr J. Stubbs described the work on the bio-assay of foliage fungicides and the methods of assessing systemic fungicides. Mr J. A. W. Turner demonstrated the *Alternaria solani* method of testing foliage fungicides. The experimental gardens and trials were also visited.

Members received generous hospitality, lunch being provided at the Royal Ascot Hotel, and tea in the canteen on the Laboratories site.

At the end of the day the President of the Society thanked Mr Tipler and his colleagues on behalf of the members for providing such an interesting well organized programme and excellent catering.

C. C. V. BATTS
Secretary, Plant Pathology Committee

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A. A. PEARSON & R. W. G. DENNIS: *Revised list of British Agarics and Boleti*. Ex Vol. 31, Pts. 3 & 4. 1948. Price net, 5s. Postage, 3d.

J. RAMSBOTTOM & F. L. BALFOUR-BROWNE: *List of Discomycetes recorded from the British Isles*. Ex Vol. 34, Pt. 1. 1951. Price net, 5s. Postage, 3d.

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INSTRUCTIONS TO AUTHORS

Contributors are asked to be clear and concise, and to use a recent issue of the *Transactions* as a guide to the arrangement of headings and subheadings, explanations of plates and figures, references to the literature, and other details. Each paper should start with a short summary.

The standards adopted in the *Transactions* are those outlined in the Royal Society's pamphlet, *General Notes on the Preparation of Scientific Papers* (1950, Cambridge University Press, 200 Euston Road, London N.W. 1, price 2s. 6d.). An exception is that in the *Transactions* citations of references to literature, although based on the Harvard system, include the full titles of the papers and complete page numbers. Titles of journals are abbreviated in accordance with *A World List of Scientific Periodicals*, 1952.

The scientific names of genera and species are printed in italics and should be underlined in the typescript. The title of the paper, headings, and subheadings may be in capitals, but should not be underlined.

The attention of authors proposing new taxonomic groups is drawn to the need to give an adequate description and figure, and to designate the types as required by the *International Code of Botanical Nomenclature*. The description of a new species should be accompanied by a figure, and whenever possible the type specimen should be deposited in one of the national herbaria.

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